

Science and Mathematics Education Centre

**Investigating Differences in Understanding of Vocabulary in
Secondary Science**

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Doctor of Philosophy
of
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DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

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ABSTRACT

One of the main elements to the crisis in science education in Australia today is the evidence that students' attitude to science decreases as they progress through secondary school, leading to a decrease in participation in post-compulsory science subjects (Tytler, 2007). This reduction in participation ultimately leads to a decrease in Australian science teachers and science-qualified workers.

There are many factors which influence students' attitudes to science, including interpersonal teacher behaviour and the science learning environment. The aim of this study is to investigate differences in Year 7 and 8 students' understanding of different types of science vocabulary: concrete, instructional and conceptual; and students' attitude to science. A diagnostic reading test and two surveys are used to collect quantitative data to investigate correlations between understanding of different types of vocabulary; vocabulary understanding and attitude to science; and group membership. It also investigates whether or not the presence of a language learning disability has an impact.

The study incorporates an overview of the literature, including vocabulary acquisition, the relationship between vocabulary and reading comprehension, the language of science, the academic impact of language learning disabilities and issues relating to attitude to science.

The study concludes there were no significant year-level or gender differences for understanding of science specific vocabulary. Male participants had a more positive attitude to science although female participants' attitudes were still positive. Students who performed well on instructional and conceptual vocabulary tasks were likely to have a more positive attitude to science. Finally, the presence of a language learning disability (diagnosed or undiagnosed) has a clear academic impact. Membership of this group of students had a medium effect size on understanding of concrete and instructional vocabulary and a large effect size on understanding of conceptual vocabulary and attitude to science. The study found that students with a language learning disability, and students experiencing difficulties with instructional and

conceptual language, are more likely to have a less positive attitude to science than their peers.

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LIST OF ABBREVIATIONS

ACER	Australian Council for Educational Research
AISV	Association of Independent Schools Victoria (currently known as Independent Schools Victoria)
CELF-4	Clinical Evaluation of Language Fundamentals – fourth edition
CLES	Constructivist Learning Environment Survey
DLT	Diagnosed language learning disability
LaCAL	Language Concepts to Access Learning
LINCS	Language in Classrooms Program
LLD	Language learning disability
OECD	Organisation for Economic Co-operation and Development
PAT-R	Progressive Achievement Tests - Reading
PISA	Program for International Student Achievement
PR13	Stanine 1-3 on PAT-R
PR47	Stanine 4-7 on PAT-R
PR89	Stanine 8-9 on PAT-R
PWLD	Presenting with a language learning disability – not formally diagnosed
QCA	UK Qualifications and Curriculum Authority
RCT	Randomised controlled trial
SSLCP	Secondary Schools Language Consultancy Program
TIMSS	Trends in International Mathematics and Science Study
TOSRA	Test of Science-Related Attitudes
VC	Concrete science vocabulary
VCN	Conceptual science vocabulary
VI	Instructional Science Vocabulary

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

According to two international reviews of achievements in science (Trends in International Mathematics and Science Study – TIMSS, and the OECD Program for International Student Achievement - PISA), Australian secondary school students' levels of achievement have dropped over the past decade, compared to other countries (Australian Council for Educational Research, 2011; Thomson, De Bortoli, Nicholas, Hillman & Buckley, 2011). Year 4 students' scores in PISA were significantly higher than the international average and have increased over time, although not at statistically significant levels. On the other hand, Year 8 students' average scores in the 2007 TIMSS declined a statistically significant 12 points. There has been a lack of change in scientific literacy achievement levels between PISA 2006 and PISA 2009, and no significant differences for gender (Thomson et al., 2011). Australia's overall ranking dropped from fourth to tenth due to the lack of change and significant improvements made by other countries, such as Singapore and Korea (Thomson et al., 2011).

There are a number of reasons put forward for the change of rankings for countries such as in the Russian Federation and Slovenia. In Slovenia, one change in science pedagogy has been the reduction, by half, of practical classes. Prior to this, Slovenian science students typically conducted science experiments in every class. Research indicated that higher levels of experimentation related to lower levels of students achievement (Pavesic, 2008). In the Russian Federation, some of the change in ranking is attributed to modifications to their science text books. Recent text books in these countries have mirrored TIMSS testing, including more physical sciences, less narrative, more activities, colourful pictures and less text (Geske & Geske, 2010).

While TIMSS and PISA testing attempts to mirror the linguistic developmental levels of students as they move from primary school to secondary school, the

vocabulary used in secondary school is more complex and abstract. Without explicit vocabulary instruction, which includes developing word meanings and word learning strategies, students are unlikely to develop a deep knowledge of the secondary science vocabulary they need to understand science concepts, comprehend science texts and engage in scientific investigations. All students need subject-specific vocabulary to be explicitly taught (Marzano & Pickering, 2005). This is even more critical for students with language learning disabilities.

Many students with a language learning disability struggle academically as they progress through school (Gambrell, Palmer, Codling, & Mazzoni, 1996), science included, possibly due to the language demands of the subject. Anderson and Nagy (1991) reported that 5.5% of words that students are expected to read in a typical text are unknown. Understanding 95% or more of words in a text is considered appropriate for engagement and learning (Schmitt, Jiang & Grabe, 2011). For students with a language learning disability, this percentage is likely to be higher. These students also appear to disengage easily from science. Research has demonstrated that teaching of subject-specific vocabulary has a significant impact on comprehension (Stahl & Fairbanks, 1986). Is it possible to identify specific areas of difficulty with comprehension of science vocabulary for students with either diagnosed language learning disabilities or presenting with language learning disabilities, as well as those struggling with science, and use this information to direct intervention?

This study investigates students' understanding of different types of vocabulary used in science: concrete, instructional and conceptual. Through the use of a custom-designed survey, it seeks to determine whether there are differences between understanding of different types of vocabulary and the performance of different student groups. Students' attitudes to science are investigated using an established attitude survey. Data are analysed in order to determine if there are differences in comprehension between student groups and types of vocabulary. Correlation between attitudes and levels of comprehension is also determined.

1.2 BACKGROUND

Anecdotally, students with language learning disabilities experience difficulties with secondary science and generally have a poor attitude towards the subject. There are many factors which may be behind this observation. This research explores one of the possible factors influencing this observation. The study investigates the differences in comprehension of various types of science specific vocabulary for students with, and without, diagnosed language learning disabilities (or those presenting with a language learning disability). Research has already shown that teaching of subject-specific vocabulary increases comprehension (Stahl & Fairbanks, 1986). However, currently there appears to be no testing tool to identify students at risk of failure or to identify the types of vocabulary with which they may be having difficulties. The Australian Council for Educational Research (ACER) recently published a new assessment tool as part of the Progressive Achievement-tests (PAT) family: PAT- Science. This comprehensive test mostly explores conceptual language involved with science, rather than concrete and instructional language. This study investigates all three types of science vocabulary.

1.2.1 Issues regarding the engagement of students with language learning disabilities in secondary science

It is the experience of the candidate (a qualified teacher and speech pathologist) that most, if not all, students with a language learning disability struggle with science in secondary school and have a poor attitude towards science classes. This is supported by the observation over many years that most students opted to miss a science class rather than any other class when timetabling individual support sessions. Science education is considered important for developing high-level comprehension skills such as classification, prediction and drawing conclusions. Developing a good vocabulary is part of this. Clay Thompson (2002) states that high order thinking skills ‘fail unless they deploy a necessary system of right word use.’ (p. 60). Students’ understanding of science vocabulary appears to be one of the factors affecting lower secondary students’ engagement in science.

1.2.2 Why is it important to investigate understanding of science vocabulary in early secondary students?

Students with language learning disabilities typically, but not always, have poor working vocabularies. They have deficits not only in the amount of words they know and can use, but also the complexity of their vocabularies is compromised. (Stothard, Snowling, Bishop, Chipchase & Kaplan, 1998). Vocabulary is critical to reading, particularly in middle – upper primary years and beyond (Spear-Swerling, 2006) where students' reading is focused on 'reading to learn', rather than the earlier objective of 'learning to read'. According to Spear-Swerling (2006), 'vocabulary weakness may affect school achievement in many areas beyond reading, including content subjects such as social studies and science.' With this in mind, it is not surprising to find that the majority of students with language impairments struggle with subjects such as science. This is possibly due in part to the amount and complexity of the vocabulary required to comprehend secondary science concepts accurately (Woodward & Noell, 1991).

Teachers need to know which students are likely to experience difficulties with the language of science and how to assist these students. Conservatively, 10 – 15% of students have a learning difficulty (Bargerhuff, Kirch, Turner & Wheatly, 2005), but in Victoria, Australia, due to government policy, only 0.01% of students with a severe language disorder will receive funding (Speech Pathology Australia, 2006). In the independent sector, secondary students no longer receive funding for speech therapy (Association of Independent Schools Victoria, 2008). The prevalence rate of students with language impairments is up to 16% according to data from McLeod and McKinnon (2007). It is important to equip schools and teachers with useful tools for identifying students at risk, then proven techniques can be used to the best advantage. There have been general studies which have trialled programs to support secondary school students with language impairments, including the current University of Sydney program, Language in Classrooms Program (LINCS) and the Secondary Schools Language Consultancy Program (SSLCP) run by Independent Schools Victoria. LINCS 'provides coaching and information dissemination by Speech Pathologists to mainstream secondary teachers, in the use of a range of classroom-based language modification and accommodation techniques'...[in

order]... ‘to create more ‘language accessible’ environments in secondary school classrooms’ (Starling, Munro, Togher & Arciuli, 2011a, p. 29). The SSLCP similarly provides information sessions, student observation and feedback sessions and targeted workshops to increase teacher awareness and understanding of language impairments, as well as provide an opportunity to implement strategies within classrooms. Eadie, Nilsen and Forwood (2010) found that students with language impairments had a less positive attitude to school than their non-language impaired peers. However, this changed when teachers in their secondary schools took part in a structured program to increase teacher understanding, use of strategies and relevant resources.

There is a body of research which supports strategy-based intervention for students with language learning disabilities. This includes explicit guidance in planning, performing and evaluating (Lenz, Ellis & Scanlon, 1996). A 2008 systematic review by Starling, Munro and Togher (as cited in Starling et al., 2011a) found only 20 randomised controlled trials (RCTs) targeting language intervention for adolescent students with language impairments. The review did not find any RCTs for supporting vocabulary development in adolescent years. There is clearly limited literature and research in the area, although Starling et al. (2011a) indicated that there were at least two studies underway which were looking at the effectiveness of direct instruction for students with language impairments (Joffe, 2011; Wilson, Nash & Earl, 2010). This study includes students with language impairments as well as students with a cross-section of abilities and seeks to add to the research about learning subject-specific vocabulary.

1.2.3 Subject-specific Vocabulary

There are several important skills and strategies that students need to be taught in order to access the curriculum (Marzano, Pickering & Pollock, 2001). It is well known that vocabulary knowledge is crucial for the development of reading comprehension skills and written expression (Starling et al., 2011a). One of the strategies teachers should use is the direct teaching of subject-specific vocabulary (Marzano & Pickering, 2005; Sim, 1998). Swanborn and de Glopper (1999) found that students with a low academic performance comprehended very little written text.

When direct teaching of specific subject vocabulary was introduced to classes, students' comprehension increased by up to 38% (Stahl & Fairbanks, 1986).

An extensive review of the literature, correspondence with the UK Qualifications and Curriculum Authority (QCA) and discussion with consultants at the Australian Council for Educational Research (ACER) has revealed that there does not appear to be a suitable assessment tool. (There is a comprehensive list of mathematics vocabulary in the UK National Numeracy Strategy.) A systematic review of the literature has not revealed any research relating to the specific science vocabulary necessary for success in science, although there are many lists available (Beck, McKeown & Kucan, 2002; Marzano & Pickering, 2005; Rinaldi, 2005), as well as research into how to teach science vocabulary (Marzano & Pickering, 2005; Marzano, 2007; Parsons, Law & Gascoigne, 2005; Sim, 1996). The literature review indicated a lack of research specific to the investigation and no research was found about language learning disabled students' comprehension of science-specific vocabulary and attitude to science in comparison with other non-impaired peers. In this study it was therefore important to investigate language learning disabled students' comprehension of science-specific vocabulary as well as their attitude to science.

1.2.4 Attitudes to Science

Links between vocabulary comprehension levels and attitudes to science were explored. There have been many research projects which have investigated students' attitudes to science and there are a number of tools available (CLES, TOSRA). Differences between attitudes to science in primary school and secondary school have been identified, in part due to changes in teaching methodologies, relevance of subject matter and lack of connection with interests and experiences (Koul & Fisher, 2005). Students' attitudes towards their teachers have been investigated (Koul & Fisher, 2005; Reid, 2007) as well as their perceptions of science and science classes (Koul & Fisher, 2005). Teacher interpersonal behaviour and its influence on students' attitudes to science have been investigated (Reid, 2007) but there appears to be little, if any, research into any relationship between vocabulary competency and

attitude to science. In this thesis, correlations between vocabulary understanding and attitudes to science were investigated.

1.2.5 Vocabulary Comprehension

It is advantageous to ascertain similarities and differences in vocabulary comprehension between students with a diagnosed language learning disability and students performing at various levels academically. This would allow teachers to be more informed about the vocabulary needs of their students. Ideally, a science vocabulary survey could be used to identify students requiring additional input and teaching of specific vocabulary. It may also identify patterns in the types of vocabulary that particular groups of students have difficulties with, for example, instructional vs. conceptual. Sim (1996) noted differences between the acquisition of vocabulary with a concrete referent, such as 'test tube', and vocabulary which did not relate to a specific object, for example, filament. This suggests that students' levels of understanding of concrete science vocabulary should be higher than their understanding of instructional and conceptual vocabulary due to the more abstract, less literal nature of these types of vocabulary.

The amount and complexity of unfamiliar vocabulary can interfere with access to the curriculum (Starling et al., 2011a) and, this study proposes, students' attitudes to school. There is a continuous introduction of subject-specific academic vocabulary across the secondary school curriculum (Baumann & Graves, 2010), referred to as Tier 3 vocabulary by Beck, et al., 2002. Beck and colleagues developed a three-tiered organisational structure for the acquisition of words. Tier 1 consists of high frequency, everyday words which usually do not need explicit teaching. Tier 2 words consist of high frequency words which are used across domains but which are 'less likely to be learned independently' (Beck et al., 2002, p. 9). Tier 3 words belong to specific domains and are low frequency words. It is recommended by Beck et al. (2002) that Tier 2 words are prioritised, however subject teachers also need to take responsibility for teaching Tier 3, or subject-specific words (Marzano & Pickering, 2005). Considering that most language learning disabled students have deficits in the number of words they know and the complexity of these words (Stothard et al.,

1998), it is likely that they have not mastered Tier 2 words by the time they are expected to be understanding and using Tier 3 words in secondary school.

It is important for teachers to have an awareness of the learning needs of students within their science classes, in particular the impact that different types of vocabulary can have on engagement. This understanding may lead to an increase in the use of evidence-based activities to develop student comprehension and increase self-efficacy.

1.2.6 Gaps in the Literature

As part of this research, a systematic literature review has indicated that there is little if any research about comprehension of different types of science vocabulary, and differences in comprehension levels between students presenting with a language learning disability (diagnosed or not) and students with no language learning disabilities. Orange (2007) noted that there were few studies/research about students with learning difficulties and science education. This is also the conclusion of the researcher. This may be due in part to the challenges of setting up a research project which involves students with a language learning disability. The process of obtaining ethics permission is often protracted which can potentially deter researchers from pursuing this avenue of research. When research has occurred, there can sometimes be an unwillingness to publish findings.

1.3 AIMS

The aim of this study is to investigate whether or not there are differences in understanding of secondary science vocabulary between groups of students, in particular students with a language learning disability, and ascertain if there is a link between levels or types of understanding and attitude to science. The consequent research includes the design of a science vocabulary survey tool to identify students who may be at risk of experiencing difficulties with science in secondary school. The study also aims to determine if there are differences in understanding of different types of science vocabulary between students with a language learning disability (diagnosed or undiagnosed) and students with a range of reading comprehension

levels. It also investigates whether or not there are differences in attitudes to science between these groups.

1.4 RESEARCH QUESTIONS

There are differences in the ways in which vocabulary is learnt, with non-concrete words more difficult to learn than words with a concrete referent. There is also a change in attitude to science as students move from primary to secondary classrooms (Speering & Rennie, 1996). This study aims to look at differences in understanding of science vocabulary and attitude to science. Therefore, the following research question arises:

- What are the mean scores of the whole sample on the Attitude Scale and the Science Vocabulary Survey? (Research Question 1)

In addition to investigating overall differences, the study aims to investigate differences in the understanding of different types of vocabulary: concrete, instructional and conceptual. It seeks to investigate any links between comprehension of vocabulary and attitude to science. It also investigates any differences according to year-level, gender and group membership, hence the questions:

- Are there associations between Science Vocabulary Survey Scales? (Research Question 2)
- Are there associations between attitude to science and comprehension of science specific vocabulary? (Research Question 3)
- Are there differences in the attitudes and comprehension of various types of vocabulary, that is, concrete, instructional and conceptual, between different student groups? (Research Question 4)

One of the main aims of the research is to determine whether or not there are differences in comprehension of science-specific vocabulary between different groups of students. As a result, the following question arises:

- Are there differences in science vocabulary knowledge between students with a language learning disability (diagnosed or undiagnosed) and students without a language learning disability? (Research Question 5)

Finally, the research seeks to review responses to individual items on both the Attitude Scale and the Science Vocabulary Survey. This leads to the following question:

- What are the students' responses to individual items on the Attitude Scale and the Science Vocabulary Survey? (Research Question 6)

1.5 RESEARCH METHOD

Quantitative data were gathered from students in Years 7 and 8 attending secondary schools in Victoria, Australia. Three assessment tools were used: The Australian Council for Educational Research (ACER)'s Progressive Achievement-tests – Reading (PAT-R), the Ten-Item Attitude Scale (Henderson, Fisher, & Fraser, 2000) and a candidate-generated Science Vocabulary Survey. Students were assigned to one of five groups as outlined in Figure 1.1. Students with a language learning disability were grouped according to whether or not their language learning disability had been formally diagnosed. They did not complete the PAT-R. Students not identified with a language learning disability were grouped according to the results from the PAT-R. All students completed the Ten-Item Attitude Scale and the Science Vocabulary Survey. Data were analysed to establish any correlations between groups and tests. The research methodology is discussed in greater depth in Chapter 3.

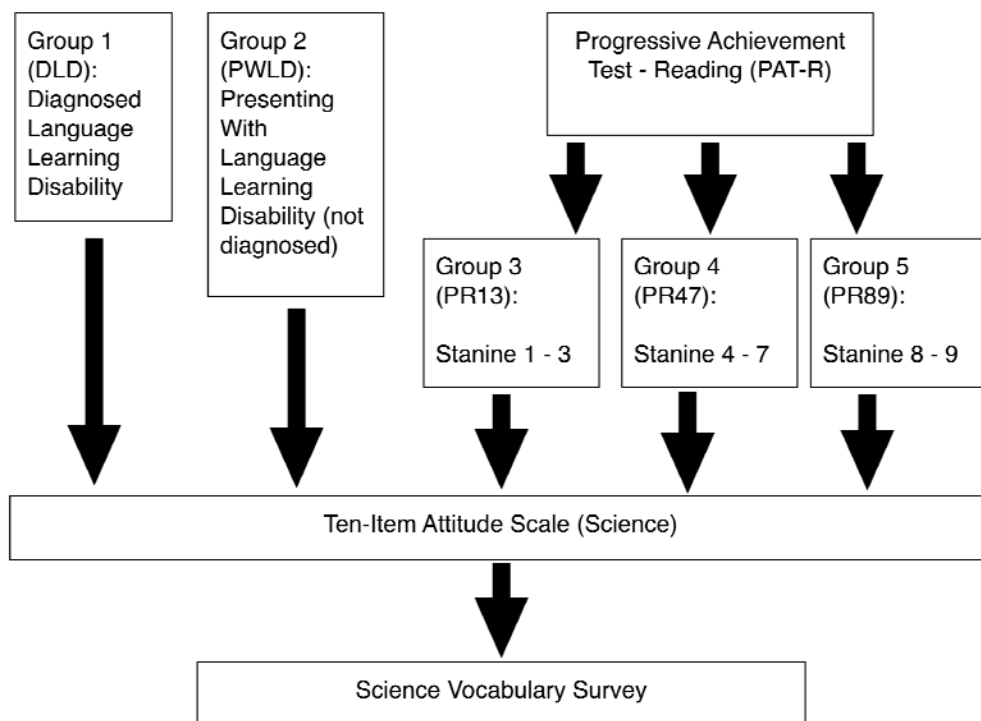


Figure 1.1. Grouping of participants and order of data collection.

1.6 SIGNIFICANCE

In terms of theoretical significance, as mentioned previously, there has been little published research about language learning disabled students' understandings of secondary science vocabulary and links to attitude to science, and therefore engagement. This study aims to add to this small and hopefully increasing body of knowledge.

Research has shown that teaching specific academic vocabulary increases students' comprehension levels significantly (Stahl & Fairbanks, 1986). Laflamme (1997) reported that the single most important factor contributing to reading comprehension was vocabulary knowledge. Action research by the candidate supports this. There is a considerable amount of literature, which provides guidance in this area. Beck et al. (2002) indicated that direct teaching of 10 words per week could make a significant difference. Nippold (2002) states that teachers need to develop students' literate

lexicon. Each subject area is different so secondary school teachers need to take responsibility for their own area of specialisation. *Building Academic Vocabulary* (Marzano & Pickering, 2005) outlines six steps for the teaching of academic vocabulary. There are also numerous resources available for teachers to implement these guiding principles.

Students are required to study science for at least part of their secondary schooling before they are allowed to ‘opt out’ of science subjects. In order to make science in the early secondary years useful and engaging, it is important to determine which students are at risk of academic failure and disengagement from the subject. There is no current standardised test which can be used to screen secondary students’ comprehension of different types of science specific vocabulary.

A Science Vocabulary Survey could help educators to:

- Identify students at risk, both of academic failure and attitudinal issues
- Possibly identify students with an undiagnosed language learning disability
- Identify specific types of vocabulary which need to be targeted
- Generate a baseline for further intervention and measuring progress

Teachers would be provided with research-based guidelines to inform classroom practice. A greater emphasis on the teaching of vocabulary specific to science would be supported. Teachers would be provided with a range of evidenced-based practices for assisting students with vocabulary comprehension difficulties, which should enable students to increase their science vocabularies, improve scientific literacy skills and attitude to science.

From a practical perspective, information gathered from this research project may be useful for consultants involved in the design of the National Curriculum and other researchers interested in secondary science, as well as those working with students with language learning disabilities.

Data collected may be also useful for educational publishers and help direct future publications. Curriculum support teachers may also find the data and the Science Vocabulary Survey useful for identifying students and targeting specific intervention.

1.7 LIMITATIONS

As with all higher degree by research studies, there were some limitations which are acknowledged. The sample size was relatively small (197 students). It would have been ideal to include more schools in the study – only two agreed within the given time frame.

The Attitude Scale and the Science Vocabulary Survey were completed online to improve data collection, limit the amount of paper usage and to allow the use of graphics to engage students. One of the problems with the online survey was that some students did not include their group identification code on both the Attitude Scale and the Science Vocabulary Survey, therefore their responses were unable to be used as they could not be matched. It would have been easier for teachers to check that students had included their code if a paper survey and test had been used. The use of an online survey made it impossible to trace the missing codes.

1.8 ETHICAL ISSUES

Parents and students involved in the research were required to sign consent forms agreeing to participation in the project. Participation was voluntary and students were able to leave the study at any point. Details of the ethical issues are discussed more fully in Chapter 3.

1.9 SUMMARY

In summary, this study undertook to investigate the understanding of different types of science vocabulary by year 7 and 8 students, 11% of whom presented with a language learning disability. Students were also required to complete an Attitude Survey to determine their attitude to science.

There is little research on vocabulary instruction and adolescents and no apparent literature which describes the different understandings that language learning disabled adolescents may have about science vocabulary, as well as any correlations between attitude and vocabulary comprehension. There is considerable research however, which provides teachers with evidence-based approaches to developing vocabulary.

This study draws conclusions about the needs of different groups of students, the links between understanding of different types of vocabulary and attitude to science and the impact that this has on accessing the science curriculum. Recommendations on how these data may be used to improve students' understanding of science vocabulary and therefore attitude to science have been provided.

In Chapter 2, the relevant literature is reviewed. The research findings relating to vocabulary acquisition, science attitudes and achievement, subject-specific vocabulary and difficulties specific to students with language learning disabilities are reviewed. The review shows a clear need for further research into the research topic.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This study examines differences in understanding of secondary science vocabulary between groups of students, particularly those with a language learning disability. It investigates links between levels and types of understanding, and attitude to science. It explores differences in understanding of science vocabulary between students with language learning disabilities and students with diverse reading comprehension levels, as well as differences in attitudes between the different groups in the study.

Review of the literature relating to the research topic: Investigating Differences in Understanding of Secondary Science Vocabulary required the exploration of many different areas, including vocabulary acquisition and development, links between vocabulary and comprehension, student attitudes to science, issues for students with language learning disabilities and strategies for teaching science vocabulary. An overview of the research in each area is outlined in Chapter 2 and provides a justification for the research project.

2.2 VOCABULARY ACQUISITION AND DEVELOPMENT

Children develop their understanding and use of vocabulary at different rates. According to Speech Pathology Australia (2012a), by the age of two, most children use more than 50 words and talk to themselves during play. By the age of three, children are able to form sentences with an average of three or four words. At four, children use four to five words in a sentence, have an expressive vocabulary of around 900 words and can be understood by most people. By five, their sentences have become more complex and they talk about past, present and future in their conversations. They can express their feelings and should be able to speak clearly enough to be understood by anyone. Most of this language acquisition is learnt

incidentally, through play, conversation and television watching (Steele & Mills, 2011).

Between the ages of two and five, children learn vocabulary at an astonishing rate, needing a limited number of exposures to a word to have some understanding of its meaning. This phenomenon is sometimes referred to as 'fast mapping'. Children at this stage of their language development add 3,000 – 4,000 words per year to their receptive vocabulary. According to Hart and Risley (1995, 2003) typically developing children need to hear at least 33 million words by the age of three years. After the age of five, vocabulary acquisition slows down, with children needing around 12 encounters to learn new words, although children are still acquiring 2,000 – 3,000 words per year (Nagy & Scott, 2000).

Spoken language tends to use more frequently used words than written language. When speaking, meaning is conveyed not only through word choice but also non-verbal language, such as facial expression and tone of voice. For meaning to be conveyed accurately in written form, precise words need to be selected and these are often words which are not regularly used in everyday social language. Words found in written language are often more complex, so by the time students reach upper primary, reading is used as a tool for learning (Spear-Swerling, 2006). For secondary school students, much of their reading at school is associated with text books and Internet research.

The importance of a language rich environment is very clear when its impact on the development of vocabulary is considered. Children's oral language experiences are related to vocabulary growth (Tabors, Beals & Weizman, 2001). Hart and Risley (1995) conducted a longitudinal study into children's everyday family experiences with language and interaction up to the age of ten. Significant differences were observed with the number of words children were exposed to depending on their socioeconomic background. Based on the information collected, the following extrapolations were made regarding number of words exposed to in a year: 11 million for the average child in a professional family, 6 million words for the average child in a working class family and 3 million words for a child in a family on welfare. Children with a language-rich environment clearly have a distinct advantage

by the time they ready to start school and learn to read. They need to be exposed to a large number of words but the quality of the interactions they have with others is equally as important. 'The more content-rich, shared interactions a child has with responsive caregivers, the more his vocabulary will grow.' (Dealy, Pacchiano, & Shimpi, 2007, p. 1).

Dale (as cited in Francis & Simpson, 2003) outlined four stages of vocabulary development 'which ranged from no knowledge of the word to an ability to use and remember the word' (Francis & Simpson, 2003, p. 66). These stages were explored later by Stahl (1999) who placed word knowledge on a continuum whereby students moved between 'no knowledge of a word's meaning to full and flexible knowledge of a word's meaning' (Francis & Simpson, 2003, p. 67). Each of the four components makes a long-term contribution to vocabulary growth (Snow, 2002). Developing a deep understanding of new terms is a gradual process (Beck & McKeown, 1991) and requires students to be able to use words in different contexts (Nagy & Scott, 2000). Beck and McKeown (1985) proposed a three tier model of vocabulary difficulty, with Tier 1 consisting of high frequency words which do not require explicit teaching, Tier 2 words which consist of less frequent words which are not learnt in context and therefore need general instruction, and Tier 3 words which are subject-specific and are therefore usually only relevant to the academic subject areas being studied. These words need explicit instruction.

Graves (2000) proposed that a comprehensive model for vocabulary development must include wide reading (Cunningham & Stanovich, 1998), direct teaching of individual words (Beck et al., 2002; Stahl & Fairbanks, 1986), teaching word learning strategies (Edwards, Font, Baumann & Boland, 2004) and word consciousness (Blachowicz & Fisher, 2006; Nagy & Scott, 2000). Each component is equally important and necessary for development of language and literacy skills.

There are differences in the way in which different types of vocabulary are learnt. Sim (1996) highlighted the differences between learning words with a concrete referent, for example, test tube, and a non-concrete referent, for example, energy. Non-concrete words were more difficult for students to learn, possibly due to their more abstract nature (Woodward & Noell, 1991). It was important to include both

concrete and non-concrete vocabulary in the Science Vocabulary Survey based on these findings.

2.2.1 Importance of vocabulary development

A well-developed vocabulary is important for a number of reasons. There is a large body of research, which supports a link between vocabulary levels and general comprehension (Foil & Alber, 2002; Pearson, Hiebert & Kamil, 2012; Stahl & Fairbanks, 1986) and reading comprehension (Bos & Anders, 1990; Bryant, Vaughn, Linan-Thompson, Ugel, Hamff & Hougen, 2000; Foil & Alber, 2002; Francis & Simpson, 2003; Pearson et al., 2012; Snow, 2002; Spear-Swerling, 2006; Stahl & Fairbanks, 1986; Stanovich, 1986), with the volume of reading being a powerful predictor of differences in vocabulary and subject knowledge (Cunningham, 2005). Vocabulary is one of the five essential skills, along with phonemic awareness, phonics, fluency and comprehension, necessary for literacy development (National Reading Panel, 2000).

Expressive vocabulary knowledge is a strong predictor of reading ability and comprehension (National Reading Panel, 2000). A child's speaking and listening vocabulary is likely to be more developed than its reading and writing vocabulary. The gap between these vocabularies narrows with age, however it is likely that an adult's receptive vocabulary will be greater than expressive vocabulary (Baumann, Edwards, Boland & Font, 2012). This gap between vocabulary types is also supported by the norms for the Word Classes subtest of the Clinical Evaluation of Language Fundamentals – 4 (CELF-4) where the raw score for understanding word classes is usually higher than the raw score for explaining word classes (Semel, Wiig, & Secord, 2003).

There is a great demand for well-developed literacy skills beyond school and as technology provides opportunities to increase the amount of information generally available to the public, the need to develop adequate literacy skills, including information skills is vital.

Development of vocabulary and grammatical skills is also fundamental for the progression of critical thinking and higher order thinking skills including analysing, evaluating and creating (Clay Thompson, 2002). Students need to be able to do more than just choose a word when thinking; they need to have a bank of usable (internalised) words from which to make their selection (Clay Thompson, 2002). Learning vocabulary is metalinguistically challenging, requiring a degree of abstract thinking (Nagy & Scott, 2000). Students need to be able to make inferences and put words into context, in order to learn the meaning of new words which are encountered in reading (Sternberg & Powell, 1983). This is supported by observations that students with poor reading comprehension skills usually find the high level thinking questions involving inferencing and evaluation difficult.

Past studies have highlighted the impact that reading comprehension ability, which is linked to vocabulary development, has on performance. Visone (2010) found that sentence length, vocabulary choices and the nature of questions, all have an impact on student performance in tests. Vocabulary is fundamental to comprehension of text (Bryant, Goodwin, Bryant & Higgins, 2003). Knowing word meanings, relationships between words and the context of new vocabulary has a positive effect on comprehension (Blachowicz & Fisher, 2004).

2.2.2 Vocabulary Development and Students with Language Learning Disabilities

When considering the acquisition and development of vocabulary in students with language learning disabilities, it is necessary to understand some of the differences as well as the ways in which students may present, particularly in the classroom, as teacher identification is an important step in the initial identification process. Once students are identified, it is important to understand their specific needs and the impact that this has on academic engagement and achievement. Teachers need to know how to support the continued vocabulary development of students with language learning disabilities.

2.2.2.1 Identification and Presentation

It has been suggested that 10 – 15% of students have a learning difficulty (Bargerhuff et al., 2005). Other researchers indicate that the level is higher (McLeod & McKinnon, 2007). In Australia, approximately 577, 000 school-aged children have difficulties with language (Speech Pathology Australia, 2012b). What is known is that, for many students with language disorders in secondary schools, they are undiagnosed, underserved and unserved (Starling, Munro, Togher & Arciuli, 2011b; Nippold, 2010). An Australian study by Smart, Prior, Sanson and Oberklaid (2005) found that 80% of children identified with a language learning disability in primary school still experienced difficulties with literacy tasks in secondary school.

As noted previously, students with learning disabilities, including language disorders, present in many different ways. It is important for teachers to be aware of the impact that students' difficulties have on their academic performance and access to the curriculum. Difficulties with oral and written language pose a particular problem in the text-focused education system, particularly as students move through to secondary school where text becomes more dense and abstract (Brent, Gough & Robinson, 2001). According to Spear-Swerling (2006), up to 75% of children with specific language impairments have reading difficulties and there is a clear risk of later academic difficulties (Vance & Clegg, 2010). It is well known that students with language learning disabilities are at risk of struggling academically (Conti-Ramsden, Durkin, Simkin, & Knox, 2009; Conti-Ramsden & Durkin, 2012; Gambrell et al., 1996; Snowling, Adams, Bishop & Stothard, 2001) and their language learning disabilities interfere with their access to the school curriculum (Starling, Munro, Togher, & Arciuli, 2011b).

While normally developing children learn words incidentally and initially with few exposures, students with language learning disabilities are not usually as proficient as their peers (Kan & Windsor, 2010; Nash & Donaldson, 2005). They need more exposures to words than their normally developing peers (Rice, Buhr & Nemeth, 1990). When this is provided, their word learning improves (Nash & Donaldson, 2005; Riches, Tomasello, & Conti-Ramsden, 2005). The implications of this are that schools need to provide rich oral language environments with repeated exposures to

new words, particularly for students with language learning disabilities (Steele & Mills, 2011). It is important however, that repeated exposures take place over time, rather than in one concentrated session (Nagy & Townsend, 2012). McKeown, Beck, Omanson and Pople (1985) found that after four encounters with new words, students did not really have a good understanding of these words, however, after 12 encounters, their understanding was deeper.

Gray (2006) found that pre-school children with normal language acquisition had significantly better receptive language than children with specific language impairments. The difference between receptive vocabulary levels increased at age six, around the time that many students start school. “The number of words in a child’s vocabulary is an indicator of linguistic health and a factor in his or her ability to use language in varied contexts and for multiple purposes” (Richgels, 2004, p. 473).

Children with language learning disabilities often have fewer encounters with vocabulary (Stanovich, 1986). There are numerous reasons for this including frequent poor word pronunciation (Gathercole & Baddeley, 1990; Goldsworthy, 2003; Graf Estes, Evans, & Else-Quest, 2007) which affects their ability to store the phonological representation of words accurately, therefore having an impact on word retrieval. Deficits in phonological components of word learning are a feature of students with language learning disabilities (Gathercole & Baddeley, 1990). Students with poor phonological short-term memory are likely to experience difficulties with long-term word learning difficulties (Steele & Mills, 2011). Students also experience difficulties with semantic components of word learning (Alt, Plante & Creusere, 2004). This translates into difficulties with storing and remembering details of word meanings. Students with language learning disabilities also often have difficulties with syntactic components of word learning (Rice et al., 2000). Research has indicated that students are less receptive to syntactic cues when working out the meaning of unfamiliar words (Rice et al., 2000).

Students with language learning disabilities often use sentences which appear longer but which have less complex grammatical forms (Goldsworthy, 2003). They also use only basic elements when writing narratives (Cragg & Nation, 2006). They have

limited receptive and expressive vocabularies (Goldsworthy, 2003; Semel, Wiig, & Secord, 2003) and widely disparate vocabulary knowledge compared to their peers (Beck & McKeown, 1991; National Research Council, 1998; Snow, 2002).

Furthermore, students with language learning disabilities are more likely to have difficulties learning new words incidentally if their reading comprehension skills and oral language skills are impaired (Steele & Watkins, 2010). Steele and Watkins (2010) found that students with language learning disabilities were less likely to infer new word meanings from contexts. They also have difficulties making inferences about the meanings of new words which have been formed from a common base word, through the addition of prefixes and suffixes. This decreased morphological awareness is likely to have an impact on vocabulary size, as morphological relationships are an integral part of word learning (Hiebert & Lubliner, 2008).

Nagy and Anderson (1984) suggested that unfamiliar words in texts might be understood based on a student's understanding of a word's morphological family. Therefore, explicit vocabulary instruction is important for students with language learning disabilities, as they are less likely to make inferences about meaning based on morphological features (Nagy & Townsend, 2012). Wallach (2010) reported that intervention which focused on developing semantic and morphological knowledge for this group of students, helped to develop word and concept relations. When word parts were taught with context clues, the effect was greater as students increased their ability to infer meaning (Baumann, Edwards, Boland, Olejnik & Kame'enui, 2003; Baumann, Edwards, Font, Tereshinski, Kame'enui & Olejnik, 2002). Students with extensive vocabularies, on the other hand, usually have a well-developed knowledge of suffixes, prefixes and word origins.

Vocabulary weakness may affect school achievement beyond reading and include subjects such as science (Spear-Swerling, 2006). Comprehension difficulties are cross-curricular as all subjects require students to engage in literacy tasks. In order for students to understand and engage with a text, they need to know at least 95% of the words in the text (Schmitt et al., 2011). In a typical text, 5.5% of words are unknown (Anderson & Nagy, 1991) but for students with a language learning disability, this percentage is likely to be higher due to their reduced vocabularies

(Goldsworthy, 2003; Snow, 2002) which are also less complex (Goldsworthy, 2003; Stothard et al., 1998). Having a less complex vocabulary potentially limits a student's ability to develop critical thinking and high-level comprehension skills (Clay Thompson, 2002). This in turn is likely to have an impact on student engagement and motivation. It is the researcher's experience that when students are asked to nominate a class to miss when accessing extra assistance, science is the class which is usually selected. Science, history, geography and English are the subject areas with the most subject-specific words which students will encounter (Marzano & Pickering, 2005). A large number of the words required to comprehend secondary science concepts accurately are complex (Woodward & Noell, 1991). Abstract words need more examples than concrete words in order to be understood, (Stahl, 1999).

Developing students' subject-specific vocabulary is essential to allow students the greatest choice in future pathways. There is a considerable body of research into techniques which promote the development of academic vocabulary including Marzano's Six Step Process for Vocabulary Instruction, which is a multisensory, student-centred approach based on evidence-based research.

2.2.2.2 Research about supporting vocabulary development in the adolescent years for students with language learning disabilities

Relatively few programs target adolescents with language learning disabilities, although researchers have provided recommendations for working with this population (Nagy & Townsend, 2012; Schumaker & Deschler, 1984; Wallach, 2010, 2011). Stahl and Fairbanks (1986) found that teaching subject-specific vocabulary increases comprehension. Schumaker and Deschler (1984) highlighted the need to teach language learning strategies rather than just content. A comprehensive review of the research into vocabulary instruction for students with learning disabilities by Jitendra, Edwards, Sacks, and Jacobson (2004) indicated that there was little research on vocabulary instruction for these students. The review did find that a number of strategies were important to include in vocabulary instruction. These included teaching directly and sequentially (Biemiller, 2001) as 300 to 400 words can be taught each year (Stahl & Shiel, 1999). The words which are chosen for direct

instruction, should be both frequently encountered and important for understanding (Stahl, 1986). As it is impossible to target the teaching of all subject-specific words, due to the sheer number, it is important to identify those words which have an impact on oral and written comprehension, and are likely to be frequently read, heard or used by students. Thematic instruction in content areas was found to be important (Blachowicz & Obrochta, 2005), selection of high use words (Bravo & Cervetti, 2008) and allowing students to select words were effective strategies (Harmon, Hedrick, Wood & Gress, 2005; Jiminez, 1997).

According to Jitendra et al. (2004), direct teaching of vocabulary is most important.

Explicit instruction should also include the use of a word's context and definition, opportunities for "deep processing" (e.g., finding a synonym or antonym, making up a novel sentence with the word, classifying the word with other words, and relating definition to one's own experience), and multiple exposures to the new word ... Finally, vocabulary should be taught through productive approaches to word learning. (p. 3)

Productive approaches include looking at word parts, semantic connections between words, and using semantic mapping to illustrate relationships between words (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006; Bos & Anders, 1990; Stahl & Dougherty Stahl, 2012). Other approaches include using mnemonics, direct instruction, cognitive instruction and computer-aided instruction. Each of these approaches led to an increase in word knowledge, however in each of the 27 studies reviewed by Jitendra et al. (2004), comprehension and therefore generalisation of words was not examined. Students with language learning difficulties often have difficulty with generalisation of words (Jitendra et al., 2004) therefore it is necessary that any future explorations of successful approaches for students with language learning disabilities also include a comprehension task.

Students with language learning disabilities often have poor working vocabularies, which is linked to poor reading comprehension skills (Cunningham & O'Donnell, 2012). Students with a language learning disability are at risk of also having a reading disability (Catts, Fey, Tomblin, & Zhang, 2002). Learning vocabulary during independent reading sessions is inefficient for this group of students (Jitendra et al.,

2004). They need to be taught vocabulary and word learning skills in order to gain deep knowledge of new vocabulary (Jitendra et al., 2004, Lugo-Neris, Jackson & Goldstein, 2010). Effective outcomes can be achieved in a relatively short period of time (Jitendra et al., 2004) although it is important that teachers are well trained in vocabulary development approaches as greater results were achieved through researcher intervention than teacher intervention in Swanson, Hoskyn and Lee's study (as cited in Jitendra et al., 2004). This may be due to the greater knowledge base and specific experience of the researchers in this area, who would be considered experts, compared with classroom teachers who may be considered novices in this area.

A systematic review of randomised controlled trials (RCTs) by Starling, Munro, and Togher (as cited in Starling et al., 2011a) revealed 20 trials targeting language intervention for adolescent students, but none targeting support of vocabulary development in the adolescent years. A recent study of vocabulary intervention with primary school-age children noted the general lack of vocabulary intervention studies (Cirrin & Gillam, 2008; Steele & Mills, 2011). There appears to be little research in the area of developing academic vocabulary for secondary students with language learning disabilities, compared with students with normally developing language and literacy skills. There is a body of research to support strategy-based intervention (Lenz, Ellis, & Scanlon, 1996) but there appears to be little or no research into the differences in understanding of secondary science vocabulary for students with language learning disabilities (Orange, 2007), or links between attitude to science classes and level of understanding of secondary science vocabulary. Conducting research with language learning disabled students can be problematic. The ethics approval process is protracted as the specific needs of these students are considered. This may be a reason for the paucity of research in the area.

Adolescents with language disorders struggle with many academic tasks (Vance & Clegg, 2010; Conti-Ramsden & Durkin, 2012), due to the complex nature of the tasks and the difficulty they have communicating orally and in writing (Starling et al., 2011a). These students often produce responses which use simpler words and grammar than their peers (Goldsworthy, 2003; Nippold, 2010). In order to address some of these issues, intervention goals need to include targeting development of

precise vocabulary as well as other language skills, in multiple, authentic contexts (Nagy & Townsend, 2012). All students need to be given the opportunity to actively engage in word learning (Blachowicz et al., 2006) as students' expressive vocabulary only increases when they are provided with opportunities to verbalise meanings of targeted words (Blachowicz et al., 2006) and articulate the common theme of words (Durso & Coggins, 1991).

Students with language learning disabilities generally have smaller working vocabularies and need more exposures to words for retention and understanding, although all students need repeated exposures (Beck et al., 2002; McKeown, 1985). These exposures need to be multimodal and include opportunities for listening to, speaking, reading and writing targeted words. Explicit teaching of vocabulary using a multimodal approach which focuses on developing deeper understanding (Stahl & Fairbanks, 1986), is essential for language learning disabled students. This is also the observation of the candidate, who employs these strategies and pedagogy when working with students with language learning disabilities. In the regular classroom, these students have been observed by the candidate to be less likely to engage in oral discussions using subject-specific vocabulary, unless structured opportunities are provided and explanations of meanings have been explored beyond the provision of definitions. Students need to have opportunities to see, hear, analyse and use words in written and spoken language (Blachowicz et al., 2006). It is also important to consider different types of vocabulary which students need to understand, as well as teaching strategies.

2.3 CLASSIFICATION OF VOCABULARY

Vocabulary has been classified in different ways depending on the focus of researchers. Beck and McKeown (1985) organised vocabulary into three tiers. Words in Tier 1 are frequently heard and used and therefore do not generally require any explicit teaching in order to incorporate them into a student's working vocabulary. Tier 2 words are those words which are less frequent and often have multiple meanings. These meanings may differ according to the subject context (Hyland & Tse, 2007). Tier 3 words are described as domain or discipline specific and consist of words which are necessary to be able to access the academic language of the domain.

Tier 2 and 3 words should be explicitly taught as they are considered words outside everyday social language. However, according to Beck and McKeown's framework, vocabulary instruction should focus on Tier 2 words. They also require multiple opportunities to be read and used (Blachowicz & Fisher, 2006; Stahl & Fairbanks, 1986).

When considering academic vocabulary, these words may be divided into two classification types: general academic vocabulary and discipline specific academic vocabulary (Hiebert & Lubliner, 2008). General academic vocabulary is used across disciplines and often describes abstract concepts. These words frequently have multiple definitions, which align them with Beck and McKeown's Tier 2 words. Discipline specific words usually have one meaning and are infrequently used outside the language of the subject area. These words include the Tier 3 words proposed by Beck and McKeown.

Tier 1 words are more likely to include concrete words while Tier 2 and 3 words include more abstract words. Written academic vocabulary uses more nouns, adjectives and prepositions than in spoken language, including spoken academic language, in particular nouns (Nagy & Townsend, 2012). It was important to include nouns within the candidate-generated Science Vocabulary Survey (see Chapter 1), both concrete and abstract. Instructional vocabulary also needed to be explored. Students with processing difficulties have significant difficulties learning the differences between instructional vocabulary such as 'analyse' and 'explain' (Singer & Bashir, 2004).

Nation and Chung (2009) classified words into four vocabulary levels: high frequency, academic, technical and low frequency. The classic high frequency word list is West's *A General Service List of English Words*, which is for young English learners and while it does not include modern vocabulary associated with technological advances, it is still considered useful as it covers 80% to 90% of running words in a text (Nation & Chung, 2009).

Coxhead (2000) developed the *Academic Word List*, which consists of 570 of the most common word families in college-level texts. These words are considered

useful for identifying words or types of words for students to comprehend but not as a prescriptive, ordered program (Nagy & Townsend, 2012). The words in this list cover approximately 10% of running words in academic texts (Nation & Chung, 2009). Other word lists include *The Fry Instant Words List*, which lists 75% of words encountered in reading material and *Living Word Vocabulary* which estimates words known by school-age students. It is still considered a valid resource today (Biemiller, 2004). A more recent word list is Biemiller's *Words Worth Teaching* which includes word meanings for primary and upper elementary students, with most of the word meanings found in *Living Word Vocabulary* (Biemiller, 2012).

Marzano (2004) identified 7,923 academic terms across 17 subject areas, with history, geography, science, mathematics and English having the most diverse number of academic terms. Marzano (2010) organised 2,845 basic terms (Tier I words) and 5,162 advanced terms (Tier II words) into 420 semantic clusters, which in turn were organised into 60 superclusters. Basic terms were those that were not specific to a particular subject area and frequent enough to limit a student's understanding if they did not understand the term (Marzano, 2010). Advanced terms were also not specific to particular subject areas but they were so infrequent as to be considered non-essential for understanding English. One of the reasons for grouping the words into semantic clusters was to allow for words to be learnt in relation to other words, an essential skill for vocabulary development (Simmons & Kame'enui, 1990).

Technical words are considered those terms which are associated with a specialist area (Nation & Chung, 2009). Chung and Nation (2003, 2004) found that the level of technical words in specialised texts was higher than the level of academic terms in a general text.

Low frequency words are, as the term suggests, those words which occur infrequently and need to be explicitly taught in order for the words to be understood and the context comprehended.

There are many vocabulary lists which have been generated by academics, school networks and included in National Curriculum documents and texts. While there are

lists of words for different year levels and subject areas, there does not appear to be any list of words which are specific to the needs of students with language learning difficulties. Wendy Rinaldi's *Language Concepts to Access Learning* (LaCAL) (2005) includes vocabulary to access learning in maths, science and geography. While the program has been reported as a useful tool for students with language learning disabilities as well as students with autistic spectrum disorders (Rinaldi, 2010), the words were not collated to target these populations.

When considering the items to include in the candidate-generated Science Vocabulary Survey, it was important to consider the vocabulary classification research. Therefore, a large proportion of nouns, both abstract and concrete, were selected. The words chosen were low frequency within the wider social language context, but considered frequently occurring in the context of science, and necessary for comprehension. The nouns included in the Conceptual Vocabulary Scale were important for understanding of topics studied in lower secondary. Nouns included in the Concrete Vocabulary Scale were necessary for practical work in particular. The words included in the Science Vocabulary Survey were words that students would encounter orally and in texts. It was necessary to also consider the links between vocabulary and reading comprehension when considering student groupings and item selection for the Science Vocabulary Survey.

2.4 VOCABULARY AND READING COMPREHENSION

Students with large vocabularies have higher levels of reading comprehension. These students tend to read more, which in turn increases their vocabularies. Students with lower vocabularies have lower levels of reading comprehension and read much less (Miller & Gildea, 1987; Stanovich, 1986). Much of a student's vocabulary is developed through reading (Cunningham, 2005). Graves (2000) suggested that students learn to read 3,000 to 5,000 new words per year. By Year 8 they will have learnt approximately 25,000 words and this increases to 50,000 words and more by the end of secondary school. A Year 5 student reading for 25 minutes every day will be exposed to more than one million words of text in a year (Anderson & Nagy, 1991). According to Anderson and Nagy (1992) there are around 88,700 distinct word families in printed school English. In order to understand text, no more than

5.5% of words in a text should be unknown, however for students with a language learning disability, when they encounter texts, the percentage of unknown words is usually higher (Anderson & Nagy, 1991) and affects comprehension.

Most academic tests require a reasonable level of reading comprehension in order for students to demonstrate their understanding of concepts and information. Visone (2009) found that students with high reading comprehension levels also did well on language-based standardised tests. This supported the findings that reading comprehension levels correlate with vocabulary levels. As students move through school, the relationship between vocabulary and reading intensifies (Simmons & Kame'enui, 1990). Reading comprehension levels have been shown to have an impact on science achievement (O'Reilly & McNamara, 2007) and general academic performance (Swanborn & de Glopper, 1999). This area is complex because language is embedded in our learning. The implications are that special care should be taken when creating tests to ensure that the language component does not disadvantage students. Questions should be articulated at the easiest level in order to allow students to demonstrate their level of understanding (Visone, 2009). Dempster and Reddy (2007) found that items in the 2006 TIMSS with a high degree of sentence complexity resulted in an increase in random guessing.

Students with good reading comprehension skills perform better on vocabulary knowledge measures than those with low reading comprehension skills (Durso & Shore 1991; McKeown, 1985). The Progressive Achievement-tests – Reading (PAT-R) is a measure of learning skill and is part of a battery of tests designed by the Australian Council for Educational Research (ACER). It was designed to be administered by teachers to large groups. Research has shown that correlations between test scores and subject grades are highly significant (Fogarty, 2007).

The purpose of the PAT-R is to measure two important parts of reading skill – comprehension of factual and inferential written text. Students read a series of passages and answer multiple-choice questions relating to each passage. There are 47 multiple-choice items. The test must be completed within a 40-minute timeframe.

The measurement scale for the PAT-R (Comprehension) was developed using Rasch's mathematical model. This model purports that student achievement is captured by two parameters, known as Rasch ability and Rasch difficulty (Darr, McDowall, Ferral, Twist & Watson, 2008). Rasch ability relates to where a student is located on a scale. Rasch difficulty relates to where an item is located on a scale. When using the Rasch measurement model, the assumption is that 'skills required to respond correctly to items of a test are accounted for by a single variable' (Darr et al., 2008, p. 50). The inclusion of only items which fit this model, has resulted in a test which is a reliable and valid assessment tool, hence the reason for selecting it as part of the assessment battery.

Considering the associations between vocabulary knowledge and understanding, and reading comprehension levels, it was important to group students without language learning disabilities according to their reading comprehension levels. Based on the research, it was expected that differences would be observed between the groups' reading comprehension and vocabulary understanding levels. It was important to also bear in mind research into links between oral vocabulary and literacy development, particularly considering students with a language learning disability.

2.5 ORAL VOCABULARY

Oral vocabulary plays a key role in the development of comprehension and literacy skills (Spear-Swerling, 2006). Rich oral language experiences are critical for vocabulary growth (Beck & McKeown, 1991; Beck et al., 2002). Many students with a language learning disability may have a history of delayed speech development (Goldsworthy, 2003) and/or auditory processing difficulties (Wallach, 2011). Recent research indicates that auditory processing difficulties may not be a risk factor for academic achievement (Kamhi, 2011), however, it is important to be aware of the research about the impact of language intervention on auditory perception (Wallach, 2011).

Well-developed phonological processing skills are necessary for vocabulary growth (Snow, 2002; Blachowicz & Fisher, 2012). Phonological processing skills include the ability to detect and produce rhyme; identify syllables in words; segment words

into sounds, identify sounds in different positions within words; and manipulate sounds in words, for example, turn the ‘m’ in ‘mop’ into a ‘p’ and the word becomes ‘pop’. All these skills are important for not only vocabulary growth, but also for literacy skill development. Students with language learning disabilities sometimes present with phonological processing deficits so the implication is that these students are likely to have difficulties with vocabulary expansion.

Opportunities for speaking new vocabulary are a vital part of the vocabulary learning process, not only for general vocabulary acquisition but for general academic vocabulary development as well (Blachowicz & Fisher, 2006; McKee & Ogle, 2005; Stahl & Fairbanks, 1986). Students need multiple opportunities to read and use words in multiple contexts in order to own the words they see, hear and use (Nagy & Townsend, 2012).

The 1986 *Progressive Achievement-tests in Reading Teacher’s Handbook* indicates that performance on a vocabulary test ‘is the best single measure of verbal skill’ (Darr et al., 2008, p. 50).

Students need opportunities to develop their oral language skills in order to develop their vocabularies and literacy skills. If students are identified as having difficulties with different types of science vocabulary, as included in the Science Vocabulary Survey, then the implications are that these students need to be provided with structured opportunities to develop their oral language skills and written language skills within science as well as other contexts. Vocabulary skills have an impact on many aspects of schooling, as reviewed in the following section.

2.6 VOCABULARY AND GENERAL ACADEMIC SUBJECTS

Results from the Third International Mathematics and Science Study (TIMSS) indicate that vocabulary skills can be used as an indicator of ‘a wider range of skills in school learning’ (Darr et al., 2008, p. 65). This is also supported by the work of Townsend, Filippini, Collins and Biancarosa (2012) where students’ general academic vocabulary knowledge explained the variance in achievement in subjects

such as mathematics, English and science. Students with higher academic vocabulary knowledge scored higher than those students with lower academic vocabulary scores. According to results of a word knowledge test administered to students who participated in TIMSS in 1994, vocabulary knowledge accounts for approximately one third of the variation in mathematics and science achievement (Darr et al., 2008). Other studies have shown that for science achievement, vocabulary knowledge correlates almost as highly as reading comprehension. This finding is cross-cultural, with data from 21 different countries supporting this explanation (Darr et al., 2008). Therefore, a vocabulary test should be able to be used as an indicator of comprehension skills. A science vocabulary survey should be an indicator of science comprehension skills.

2.7 THE LANGUAGE OF SCIENCE

Each subject or discipline has its own unique language which is different to the social language used outside of the school classroom. Each discipline uses reading and writing in different ways (Cervetti & Pearson, 2012). Science words are usually ‘significantly longer and have more conceptually complex definitions’ than words found in narratives (Hiebert & Cervetti, 2012, p. 331). Single ideas are often represented by more than one word, for example, light energy. The social language of science is also different from the social language of school science, so it may be that some of the terms which students are exposed to in the classroom are not seen or heard in any other context. Similarly, many scientific words also have common meanings when only one precise meaning is required in the context of the science classroom. This means that students’ everyday understandings of science words, which have been learnt in a non-science context, can cause difficulties when they need to learn science context meanings for these words (Hiebert & Cervetti, 2012). Teachers need to differentiate between common uses of words and their subject-specific scientific meanings (McKee & Ogle, 2005).

Academic language is ‘heavily layered in definitional terms and double meanings’ (Wallach, 2011, p. 8). Scientific language is highly metaphorical and often consists of implied meanings (Halliday, 1993a). Students may find this aspect of science learning problematic as developmentally, their abstract thinking skills may not be

developed until later in secondary school. Students are aware of the existence of the language of science but they can be alienated by the unfamiliar nature of the discourse (Halliday & Martin, 1993). In order to engage in academic discourse, multiple opportunities are needed to interact with, and practice subject-specific vocabulary (Manyak, 2012). It can be useful to start with commonsense knowledge to engage students, however, it is necessary for teachers to provide students with alternative scientific world views (Martin, 1993a) and use the necessary technical words to think scientifically.

Halliday (1993b) argued that scientific knowledge cannot be represented in everyday terms. Technical terms need to be understood in order to organise the world in a different way, although it was acknowledged that scientific language is sometimes presented in more complex ways than necessary. Halliday and Martin (1993) described some of the specific grammatical constructs which are used in science discourse. The use of scientific verbs is rare (Martin, 1993b) with verbs and adjectives frequently reworded into nouns (nominalisation). Other features include the use of grammatical metaphors (where one grammatical structure is substituted for another) and the use of linking words to explain relationships. Students need to be aware of the language features of scientific text types and know how to use the key grammatical structures, as well as the relevant technical vocabulary.

Halliday and Martin took a systematic functional linguistic perspective of language, viewing it as a resource for making meaning rather than expressing meaning. Science invents knowledge rather than interpreting it, as is mainly the case in humanities subjects (Martin, 1993c). Students need to know the meanings of words and associations between words in order to engage in high level thinking involving abstraction. Halliday and Martin also argued that students need to be engaged in more extended scientific writing, as it was their belief that written discourse was the key to science technicality. While their work focused on the importance of understanding and using grammatical structures featured in science discourse, they also acknowledged the interrelationship between semantics and grammar, and therefore the need to develop subject specific vocabulary.

Science language is associated with problem solving and cause and effect. Students with language learning disabilities struggle to organise their thoughts for problem solving due to their language difficulties (Buttrill, Nüzawa, Biemer, Takahashi & Hearn, 1989), which implies that they are likely to find the science curriculum difficult to access. When students are learning about science, they also need to learn the science speech genre, or how to ‘speak science’ (Scott, 2004). However, learning to ‘talk science’ is not just about learning a new speech genre, it is also about the different types of discourse which occur in classrooms between students and teachers (Scott, 2004). It is important that teachers are aware of not only the subject-specific language which they use in their classrooms, but also the different types of discourse which they use, and the impact that this can have on students.

Barnes (1971) classified teacher talk into three types: specialist language is presented; specialist language is not presented; and the language of secondary education. Specialist language presented consists of subject-specific language which teachers are aware may be a barrier to understanding, therefore the language is ‘presented’ to students to assist with comprehension. Specialist language not presented is subject –specific language which is not ‘presented’ to students because they may already have been exposed to the language, or the teacher is unaware it is being used. The language of secondary education is language which is not subject specific but is unlikely to be heard or used in everyday speech.

Students with language learning disabilities frequently have difficulties with logical connectives, especially in science contexts, yet teachers often use logical connectives in their speech (Parkinson, 2003). Teachers need to be aware of their own language choices and the impact of their discourse on all students, including those with language learning disabilities.

McKee and Ogle (2005) recommend that both general and subject-specific vocabulary needs to be introduced through conversation. It is important that opportunities for using spoken language are provided for all students. The students with the greatest need for the development of oral language skills, those with language learning disabilities, often do not participate in general discussions due to the language demands of tasks, difficulties with word retrieval or their poor self-

efficacy. It is vital that these students are provided with structured opportunities to form accurate phonological representations of new words, make connections between words and use new terms in both spoken and written forms. One program, *Word Generation*, (Snow, 2009) is an intervention which promotes discussion, debate and writing using targeted words. Participants are provided with opportunities to develop oral and written academic language skills. Key to the intervention is the explicit teaching of vocabulary within semantically rich content.

The candidate's review of the literature indicates that there is a limited amount of research in this area, therefore the investigation undertaken by the candidate should add to the current knowledge base. It is important to establish whether or not there are differences in understanding of secondary science vocabulary between students with language learning disabilities and those without, as well as between students with different reading comprehension levels. If differences are observed, this will provide important information for teachers about the types of instruction and strategies needed by these students. It should also help science teachers become more aware of the impact that vocabulary knowledge has on general comprehension, reading comprehension (especially within science texts) and following instructions. It is hoped that the information may also help science teachers to be more aware of the potential academic impact for students with a language learning disability.

2.8 ACADEMIC IMPACT OF LANGUAGE LEARNING DISABILITIES

Students with a language learning disability typically struggle to access the curriculum (Starling et al., 2011b), including science (Wellington, 2000) and their general academic performance is lower than that of their peers with normal language development (Gambrell et al., 1996). Students with a language learning disability have a clear risk of later academic ability (Conti-Ramsden & Durkin, 2012), especially with reading (Rescorla, 2005). More than 40% of students diagnosed with language disorders will have reading difficulties (Spear-Swerling, 2006). It is important to be aware that students with a history of language disorder diagnosis are at an increased risk of reading difficulties (Catts, 1993), even if they no longer meet the criteria for the diagnosis of a language disorder.

The academic impact is considerable and covers many aspects of learning. Students with language learning disabilities are not only more likely to have reduced working vocabularies and difficulties with reading comprehension; they also have difficulties with metacognition and self-questioning techniques (Sturomski, 1997) which are necessary to develop high level comprehension skills. They frequently have difficulties with organising academic tasks (Anderson, Yilmaz & Washburn-Moses, 2003; Wallach, 2011) therefore work may not be completed on time or have essential elements missing.

Students with language learning disabilities typically experience difficulties with metaphoric language. Metaphors can assist with creating powerful visual imagery, which can be used to make implicit information explicit (Wallach, 2011). This may be one of the reasons why implied information is difficult for these students to locate in texts and understand in written language.

Students with language learning disabilities usually have lower self-esteem than their peers (Eadie et al., 2010). This has important implications for learning. Snow, Porche, Tabors and Harris (2007) found a positive correlation between reading comprehension level and attitude to school. As students with language learning disabilities commonly have reading comprehension difficulties, it is likely that many of these students will have a less positive attitude to school. This obviously depends on the level of support offered to students with language learning disabilities, however, as the research clearly indicates a link between language learning difficulties, vocabulary difficulties and reading comprehension levels (Wallach, 2011), it is important to be mindful of the potential attitude students with language learning disabilities may have towards their academic life (Starling et al., 2011a).

Considering the limited number of studies which include the investigation of attitudes to school and science in particular for adolescent students with language learning difficulties, it was important to include an attitude survey as part of this study. This allowed the investigation of associations between attitude to science and understanding of secondary science vocabulary, across different groups of students, including those with diagnosed language learning disabilities and those students presenting with language learning disabilities.

2.8.1 Implications for teaching of students with Language Learning Disabilities

In order to support students effectively, teachers need to be able to identify potential language learning disabilities. Diagnosis is provided by Speech Pathologists following in-depth assessment, however, teacher identification is an important step in the diagnostic process. Teachers need to be aware of some of the presenting behaviours of language learning disabilities and recognise that these students are not only cognitively at least within the average range, but that they need to be supported in order to achieve the best outcomes.

Ideally, pre-service teachers should be provided with information about students with language learning disabilities as part of their training. The reality is that many courses either do not provide any information or resources, or it is limited. Programs such as the Language in Classrooms Program (LINCS), run by The University of Sydney, and the Secondary Schools Language Consultancy Program (SSLCP) run by Independent Schools Victoria, provide tailored information sessions, student observation and teacher feedback sessions for secondary school teachers. The main aim of these programs is to create more ‘language accessible’ secondary school environments (Starling et al., 2011a, p. 29) and provide secondary teachers with practical assistance and resources for supporting students with language learning disabilities (Eadie et al., 2010). The key to supporting students with language learning disabilities is inter-professional collaboration (Starling et al., 2011a).

It is important for teachers to be aware of the latest research, not only about students with language learning disabilities, but also about pedagogy, as at least 10% of students have a learning difficulty. In Victoria, Australia, only 0.01% of students with diagnosed severe language disorders receive funding (Speech Pathology Australia, 2006). In light of this information, it is vital that teachers have an understanding of students’ difficulties and use research-based strategies in order to enable their students to access the curriculum and improve their attitude to school.

Teachers need to be aware that poor results in reading comprehension tests may also be an indicator of possible difficulties with academic vocabulary and attitude.

Suitably qualified special education teachers, speech pathologists or psychologists should then explore students' receptive and expressive language skills, as students with poor reading comprehension skills typically have limited receptive and expressive vocabularies (Nation, 1990).

Students with language learning disabilities need exposure to rich oral language experiences (Blachowicz & Fisher, 2006; Nation, 1990; Snow, 2009). They usually have less complex vocabularies (Stothard et al., 1998) and their knowledge is considerably lower than that of their peers without learning difficulties (Beck & McKeown, 1991; National Research Council, 1998; Snow, 2002). They also often have poor word pronunciation, particularly of multisyllabic words (Goldsworthy, 2003) which impacts on accurate storage and retrieval of words.

There have been several studies which have investigated strategies which need to be used, not only to teach students with normally developing language skills, but particularly those students with language learning disabilities. There are a number of strategies and skills which students need to be taught in order to increase their in-depth knowledge of vocabulary (Marzano, Pickering & Pollock, 2001). Explicit vocabulary instruction is highly desirable for the general population as it increases comprehension (Stahl & Fairbanks, 1986) but it is particularly important for students with language learning disabilities (Spear-Swerling, 2006; Wallach, 2010). A number of approaches are helpful, including the use of mnemonics, meaning of word parts, semantic mapping, semantic feature analysis and teaching word parts (Stahl, 1999). Use of memory devices, multiple exposures and graphic depictions coupled with direct instruction have been shown to increase reading comprehension and word knowledge (Bryant et al., 2003) and it is inferred, based on previous research (Snow et al., 2007), that attitude to school would become more positive.

Independent word learning strategies are insufficient for students with a language learning disability (Bryant et al., 2003) as well as glossaries and rote learning of definitions (Foil & Alber, 2002). Marzano and Pickering's six step process for direct vocabulary instruction is based on research into vocabulary learning. The process highlights the importance of active engagement of students in activities which include student generated descriptions of vocabulary, inclusion of graphic depictions

(Bryant et al., 2003), opportunities to explore words with multiple exposures over time (Bryant et al., 2003; Nagy & Townsend, 2012), and exploration of word relationships to provide the in-depth word knowledge necessary to increase reading comprehension, particularly in students with language learning disabilities (Simmons & Kame'enui, 1990). Students also need to be engaged in discussion about new words as this provides opportunities to clarify misunderstandings (Stahl, 1999). The most effective approaches to vocabulary instruction are ones which are integrated in the curriculum and provide opportunities to learn words each day, in all subject areas (Blachowicz et al., 2006).

According to Snow et al. (2009), the key instructional factors which promote successful learning of vocabulary are: semantically rich contexts within motivating texts, frequent exposures, opportunities to use academic vocabulary within oral and written activities, explicit instruction in word meaning and word learning strategies.

It is clear from the research that teachers need to have an understanding of the needs of students with language learning disabilities. They need to be aware of the impact that these difficulties have on students' ability to access the curriculum, as well as their attitude to school and science in particular. They also need to understand how words are learned and the gradual nature of the process of word acquisition and understanding beyond a superficial level (Blachowicz et al., 2006). Teachers need to know how to recognise students who present as language learning disabled, as this may lead to formal diagnoses and targeted support for students. One useful tool to assist teachers with identification of language learning disabled students is the Language for Learning Checklist (Van Mourik & Roberts, 2003). Identification of students is necessary to help teachers understand the need for explicit teaching of vocabulary, planned inclusion of rich oral language tasks and implementation of strategies which have been shown to support these students in their learning.

2.8.2 Supporting Students with Language Learning Disabilities

There have been several research projects which have investigated strategies that are important for the development of literacy skills. Use of memory devices and graphic organisers have been shown to increase reading comprehension levels and word

knowledge (Bryant et al., 2003). Explicit vocabulary instruction is highly desirable for all students (Marzano et al., 2001; Spear-Swerling, 2006; Stahl, 1999) but especially those with a learning difficulty (Spear-Swerling, 2006) as vocabulary growth is slower for disadvantaged students (White, Graves & Slater, 1990). In-depth word knowledge is necessary to increase reading comprehension to levels which allow students to manage the reading demands of the classroom (Loeterman, Paul, & Donahue, 2002). Vocabulary and word learning skills must be taught (Jitendra, et al., 2004) as independent word learning strategies are insufficient for students with learning difficulties (Bryant et al., 2003). Students with language learning disabilities respond well to structured learning situations (Nash & Donaldson, 2005).

Exposure to print media is very important. There is a strong relationship between exposure to print and word knowledge (West, Stanovich & Mitchell, 1993). It is noteworthy that no relationship has been shown between non-print exposure (television shows, films) and word knowledge. The amount of reading done is directly related to a student's knowledge of word meanings (Stahl, 1999). Research shows that students with language learning disabilities are more likely to have reading difficulties (Smart et al., 2005). These students are likely to struggle with reading comprehension because they lack the necessary vocabulary to understand texts (Snow et al., 2007). Students with reading difficulties are less likely to read and as a result are more likely to have a reduced working vocabulary. It is therefore important for families and educators to ensure that students are exposed to a wide range of print.

Previous research indicates that classrooms need to provide rich oral and written language environments, where students have multiple exposures to vocabulary over time, opportunities to engage in oral and written language tasks and direct instruction of vocabulary (Coyne, Cappozzoli-Oldham & Simmons, 2012; McKee & Ogle, 2005; Steele & Mills, 2011). Recent research by Cervetti, Barber, Dorph, Pearson and Goldschmidt (2012) showed that integration of literacy with science resulted in an increase in science understanding and science vocabulary.

Effective vocabulary instruction should include teaching deep meaning of words, multiple repetitions and exposures to new words, definitions and contextual information (Baumann et al., 2012; Nagy & Townsend, 2012; Stahl & Fairbanks, 1986). Graves (2006) expanded this to include active participation by students and provision of time to teach, discuss and learn words. Graves (2006) also provided advice about what should not be included in vocabulary instruction, including the looking up of meanings in dictionaries, which is not effective (Foil & Alber, 2002, Stahl & Fairbanks, 1986) or the rote learning of definitions (Nagy & Townsend, 2012). According to Nagy & Townsend (2012), there is a large body of work on vocabulary learning and instructions, which highlights the need for authentic contexts, multiple experiences and exploration of word relationships, as well as meanings.

While there is a considerable body of research which has helped inform best practice for teachers, particularly in the area of vocabulary development, there are still a limited number of evidence-based studies which have investigated intervention for adolescents with language disorders (Nippold, 2010). This study specifically includes adolescents with language disorders in order to investigate differences in understanding of science vocabulary and any associations with attitude to science. It is the observation of the candidate that students with language disorders struggle to access the secondary science curriculum. When given the option of selecting a subject to miss for individual withdrawal sessions, almost all the students accessing support chose not to attend a science class. This observation was one of the motivations for the candidate to investigate differences in understanding of secondary science vocabulary, knowing that students with language learning disabilities typically have poor working vocabularies. This study should contribute to the body of knowledge about adolescents with language learning disabilities, particularly in the area of science, in which there have been limited studies with this population.

2.9 ATTITUDE TO SCHOOL OF STUDENTS WITH LANGUAGE LEARNING DISABILITIES

There is limited research relating to language learning disabled students' attitude to school and science in particular. Eadie et al. (2010) found differences in attitude, between students with a language learning disability and their normally developing peers. Students with language learning disabilities had a less positive attitude to school. Carlisle and Chang (1996) found that these students were more likely to express doubts about being successful science learners than their peers.

2.10 SCIENCE ISSUES

There is a considerable body of research which has investigated students' attitudes to science, connections between students' perceptions of their learning environment, including teacher interpersonal interactions and their attitude (Fisher, Fraser & Cresswell, 1995; Kim, Fisher & Fraser, 2000), and gender issues (Fisher & Rickards, 1997; Khine & Fisher, 2002), particularly relating to participation, achievement and attitude. Some of these issues are referred to in the following sections.

2.10.1 Attitude to Science

Clear associations have been found between student perceptions of laboratory learning environments and their attitudinal outcomes (Kim, Fisher & Fraser, 2000; Wong & Fraser, 1996). A strong correlation has been shown between student attitude and interpersonal teacher behaviour (Eccles, 2006; Fisher, Fraser & Cresswell, 1995; Koul & Fisher, 2005), however, the correlation between interpersonal teacher behaviour and cognitive achievement is weak (Fisher, Fraser & Cresswell, 1995). Studies have been conducted in many countries with similar outcomes (Goh & Fraser, 1998; Khine, 2001; Khine & Fisher, 2002; Lee & Fraser, 2001; Lee, Fraser & Fisher, 2003). There is clear evidence that teacher interpersonal behaviour has an impact on attitude. This study seeks to explore whether or not understanding of different types of science vocabulary correlates with attitude to science, reading comprehension levels and the presence or absence of a language learning disability.

The Ten-Item Attitude Scale was the tool selected to gather information about students' attitude to science.

The Ten-Item Attitude Scale (Henderson et al., 2000) was developed from the Test of Science-Related Attitudes (TOSRA), which was initially developed by Fraser (1978). The original test was developed to measure secondary school students' attitude to science related dimensions. Students responded to statements across seven different scales using a 5-point Likert Scale. TOSRA was used in numerous studies and found to be a highly reliable tool for assessing attitude (Eccles, 2006).

In 1981, Fraser created a new questionnaire based on some of the seven scales from the original TOSRA. This was due to the high correlation between some of the scales. This new questionnaire was also found to be highly reliable (Fraser, 1981). There have been seven-item, eight-item and ten-item versions of the attitude scale, with all versions being shown to be highly reliable (Henderson et al., 2000).

The Ten-Item Attitude Scale is based on two scales from the original TOSRA: Adoption of Scientific Attitudes and Enjoyment of Science Lessons. It uses a 3-point Likert scale rather than the original 5-point Liker scale. Students have the choice of the following responses: agree, not sure, disagree. The questionnaire has been used in numerous studies and found to be reliable. It is useful for comparing different groups of students. The Attitude Scale used by the candidate was modified from the Ten-Item Attitude Scale used by Henderson et al. (2000). The fourth statement was changed from 'What we do in science are among the most interesting we do at school.' to 'I find it easy to understand the words used in science.' This modification was made to reflect the focus of the investigation: science vocabulary. This change did not affect the high reliability of the tool, as discussed in Chapter 4.

Attitudes to science have not only been investigated within classrooms but between year-levels. There have been observable differences between the attitude to science of primary students and secondary students, as well as differences as students progress through secondary school. Some of these findings are discussed in the following section.

2.10.2 Transition from primary to secondary science

Morrell and Lederman (1998) found that primary students have a more positive attitude to science than secondary school students. This is supported by results from TIMSS 2003 (Thomson, 2008). As students progress through secondary school, their attitude to science becomes more negative, with science being one of the subjects which students in general perceive more negatively than others (Speering & Rennie, 1996). There may be a number of reasons for this shift in attitude as students transition from primary to secondary science classrooms. Primary science is often taught as part of an integrated unit which incorporates literacy instruction. This has been shown to increase science understanding and science vocabulary (Cervetti et al., 2012). Science in secondary schools is typically taught as a discrete subject. Secondary science teachers may not have the same levels of expertise in teaching specific language skills, including vocabulary instruction, reading comprehension strategies specific to science texts and written expression, as their secondary English peers or primary teachers. The language used in texts and by teachers in science classes becomes more complex and abstract as students move through the secondary levels. It is proposed that this is one of the factors influencing students' attitudes to science.

2.10.3 Gender

Many studies have investigated gender issues in science (Eccles, 2006; Fisher & Rickards, 1997; Khine & Fisher, 2002). The research shows that overall, girls have a more positive attitude towards school in general (Morrell & Lederman, 1998), however, they perceive science negatively, more so than boys (Kahle & Meece, 1994; Speering & Rennie, 1996; Thomson, 2008). Simpson and Oliver (1985) found a distinct difference between the attitudes of females and males between Year 6 and Year 10, with males more positive about science than females, in all year levels except Year 9. There was a clear decline in attitude as students progressed through school as well as a less positive attitude each year, by mid-year. There are also gender differences in the way in which students perceive their teachers. Girls tend to view their science teachers in a more positive light than their male peers (Fisher & Rickards, 1997; Khine & Fisher, 2002), however, they are less likely to choose

science as a career pathway and when they do, are more likely to favour the biological sciences.

Considering issues in science education today, it is important to include a measurement of attitude to science within the study as there is a large body of research which shows that how students feel about themselves may be “the most important variable in the education process” (Simpson, Koballa, Oliver, & Crawley, 1994, p. 214) as “the key to success in education often depends on how a student feels towards home, self and school” (Simpson et al., 1994, p. 211). Opportunities to probe possible gender differences and year-level differences were considered important as the research indicates that there are differences in attitude between genders and year levels.

2.11 SUMMARY

This chapter reviewed the literature relevant to the study. While no literature was found which specifically related to differences in understanding of secondary science vocabulary, including students with language learning disabilities, there were many articles related to vocabulary, which provided valuable information for this study.

An understanding of vocabulary acquisition and development provides an understanding of why some students, particularly those with language learning disabilities, find science classes daunting. Review of the research showed a clear link between vocabulary development and reading comprehension, as well as links between learning difficulties and poor self-efficacy to school in general, and science in particular.

The research informed the types of vocabulary to be investigated and included in the candidate-generated Science Vocabulary Survey: concrete, instructional and conceptual. The PAT-R and Ten-Item Attitude Scale are both highly reliable tools, which provide information about reading comprehension skills and attitudes to science respectively.

It was clear from the literature review that this study would help to fill a gap, particularly in the areas of adolescent language learning disabilities, science vocabulary knowledge and attitude to science.

The next chapter outlines the methodology used for collecting, analysing and interpreting data. The selection processes are discussed and outlined in detail.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

There have been many research projects investigating the relationship between vocabulary and reading comprehension; the teaching of subject-specific vocabulary; and difficulties language disordered students have with vocabulary, however there appears to be little literature about science vocabulary specifically and students with language learning disabilities. Vocabulary investigations have tended to consider general vocabulary or limited science vocabulary (e.g. 10 – 12 words). This study takes a more comprehensive look at science vocabulary, as well as the relationship between students' understanding of science vocabulary and their attitude to science.

3.2 RESEARCH TITLE AND SIGNIFICANCE

The title of the research, Investigating Differences in Understanding of Vocabulary in Secondary Science, reflects the focus on secondary students' understanding of science vocabulary. The project includes the investigation of classroom engagement of early secondary science students, in particular, students with language learning disabilities. Early disengagement in science has the potential to limit students' future pathways options. By attempting to understand the impact which the level of understanding of different types of science vocabulary has on students, teachers should be better informed in terms of intervention for students with poor comprehension, who are also at increased risk of disengagement. The findings of this research project should add to existing knowledge in areas including vocabulary development, engagement in science classes, the impact of comprehension of science vocabulary on general ability students and students with language learning disabilities.

3.3 RESEARCH QUESTIONS

As introduced in Chapter 1, this chapter presents the methods used to investigate the following research questions.

As discussed in Chapter 2, Section 2.2.2 (p. 19), there are differences in the development of general language between students with normally developing language skills and students with language learning disabilities. Studies have investigated general vocabulary but not any differences in science vocabulary knowledge. Studies also indicate that as students move through secondary school, their attitude to science becomes less positive (Simpson & Oliver, 1985; Speering & Rennie, 1996).

As discussed in Chapter 2, Section 2.2 (p. 15), there are differences in the ways in which different types of vocabulary are learnt. Non-concrete words are more difficult to learn than words with a concrete referent (Sim, 1996; Woodward & Noell, 1991). In this study, the Science Vocabulary Survey includes concrete and non-concrete vocabulary. As discussed in Chapter 2, Section 2.10.2 (p. 45), there is a change in attitude to science as students move from primary to secondary science classrooms, with students' attitudes becoming less positive over time. Therefore, the first research question is:

Research Question 1:

What are the mean scores of the whole sample on the Attitude Scale and the Science Vocabulary Survey?

Students with language learning disabilities usually have poor working vocabularies (see Chapter 2, Section 2.2.2, p. 19). Students with language learning disabilities often have significant difficulties learning the differences between instructional words (Singer & Bashir, 2004) as they find it harder to learn verbs (Eyer, Leonard, McGregor, Anderson & Viescas, 2002). Science is one of the subject areas where students will encounter the most subject-specific words (Marzano & Pickering, 2005). Science language includes more nominalised words than other subjects and a

large number of science words are complex. (See Chapter 2, Section 2.2.2.1, p. 20). It is important to consider different types of vocabulary when investigating students' understanding of secondary science vocabulary. Therefore, the second research question is:

Research Questions 2:

Are there associations between Science Vocabulary Survey Scales?

Students with a language learning disability are more likely to have a negative attitude to school (Eadie et al., 2010) and question their ability to be successful science learners (Carlisle & Change, 1996). The implication is that there is an association between understanding of science vocabulary and attitude to science. There is limited research in this area, which leads to the third and fourth research questions:

Research Question 3:

Are there associations between attitude to science and comprehension of science specific vocabulary?

Research Question 4:

Are there differences in the attitudes and comprehension of various types of science vocabulary, i.e. concrete, instructional and conceptual, between different student groups?

There is a considerable body of research which has investigated students' attitudes to science (see Chapter 2, Section 2.10.1, p. 43, and Section 2.10.2, p. 45). This has included investigating gender differences, differences between primary students and adolescents and the impact of teacher interpersonal behaviour. There is little research which differentiates between students with different reading comprehension levels, students with diagnosed language learning disabilities and students presenting with language learning disabilities, thus, the fifth research question is:

Research Question 5:

Are there differences in science vocabulary knowledge between students with a language learning disability (diagnosed or undiagnosed) and students without a diagnosed learning disability?

As well as investigating associations between groups of students, it is both interesting and useful to review responses to individual items on both the Attitude Scale and Science Vocabulary Survey. This allows for the exploration of differences in individual vocabulary items, and specific attitudinal statements. Therefore, the final research question is:

Research Question 6:

What are students' responses to individual items on the Attitude Scale and the Science Vocabulary Survey?

In this chapter, the most appropriate methods of research will be discussed.

3.4 RESEARCH DESIGN

A published diagnostic reading comprehension assessment tool was used to establish reading comprehension levels in students who did not present with a language learning disability. It performed an important filtering role across the research sample.

A survey was chosen to establish students' attitudes to science as it enabled students to indicate their level of satisfaction or dissatisfaction on a continuum. An interview with each student would also have allowed them to indicate this, however due to the large sample size, this would have been an unwieldy tool due to the amount of organisation and time required. Using an online survey allowed data to be collected quickly and efficiently.

The method chosen to investigate students' understanding of science vocabulary was a survey, as it provided the best opportunity to collect quantitative data. This has great advantages for later data analysis. Aside from the individual usage of each instrument, a big advantage was the ability to use each simultaneously with large groups.

The PAT-R was selected as the instrument to group students according to their reading comprehension levels. The link between vocabulary knowledge and reading comprehension skills is clearly defined in the literature. Students with large vocabularies have higher levels of reading comprehension than those students with lower vocabularies (Miller & Gildea, 1987; Stanovich, 1986). Science achievement has also been found to be influenced by reading comprehension levels (O'Reilly & McNamara, 2007). Other studies have also shown that students with good reading comprehension skills perform better on vocabulary tasks (Durso & Shore, 1991).

The Ten-Item Attitude Scale was selected as a valid and reliable tool as shown in previous research projects (Henderson et al., 2000; Lang, Wong & Fraser, 2005). It was used to determine students' attitudes to science. The Science Vocabulary Survey was used to gather information about students' understanding of concrete, instructional and conceptual science vocabulary.

3.5 SAMPLING AND DISTRIBUTION

3.5.1 Method of Selection and Target Population

Students were selected from two secondary schools within Melbourne, to provide easy access for the researcher. Personal contact was made with the appropriate person at each school involved in the research. For one school this person was the school Principal, for the other school, it was the Deputy Head of the Middle School. Key information was provided regarding informed consent, anonymity, procedures and time commitments (Appendix A). Ethics approval processes for Curtin University were outlined to the appropriate school personnel and contact details were provided should the school wish to clarify any aspect of the research program. Guidelines for conducting research in Victorian schools were followed.

Students took home a Student Information Sheet (Appendix B), Parent Information Sheet (Appendix C), Parent Consent Form (Appendix D) and Student Consent Form (Appendix E). The information sheets outlined the purpose of the research, the tasks to be completed by the student as well as a clear statement that participation in the study was voluntary. Anonymity of information and data was also guaranteed. Parents were provided with contact details for the candidate and the candidate's supervisor in case they wished to clarify any information. Participation in the research project required active consent. Only students with signed parental and student consent forms were involved.

Male and female year 7 and 8 students (in Victoria) were grouped and coded as follows:

- 1: diagnosed language learning disability (DLD)
- 2: presenting with a language learning disability – not formally diagnosed (PWLD)
- 3: Stanine 1 – 3 on PAT-R but not identified with a language learning disability (PR13)
- 4: Stanine 4 – 7 on PAT-R but not identified with a language learning disability (PR47)
- 5: Stanine 8 – 9 on PAT-R but not identified with a language learning disability (PR89)

The target population consisted of secondary students in level 5 (Years 7 and 8 in Victoria). This population was chosen as research indicates that it is in the transition from primary education to secondary education that many students become disengaged (Morrell & Lederman, 1998). During primary school, students' experiences of science are often within an integrated unit which incorporates literacy instruction. This has been shown to increase science understanding and science vocabulary (Cervetti et al., 2012). In secondary school, science is generally taught as a discrete subject. Texts become more dense and vocabulary more complex (Woodward & Noell, 1991).

The students were grouped according to presentation of a language learning disability (diagnosed or not), or no language learning disability. Students without a language learning disability were grouped according to their scores on the PAT-R (see Figure 3.1.).

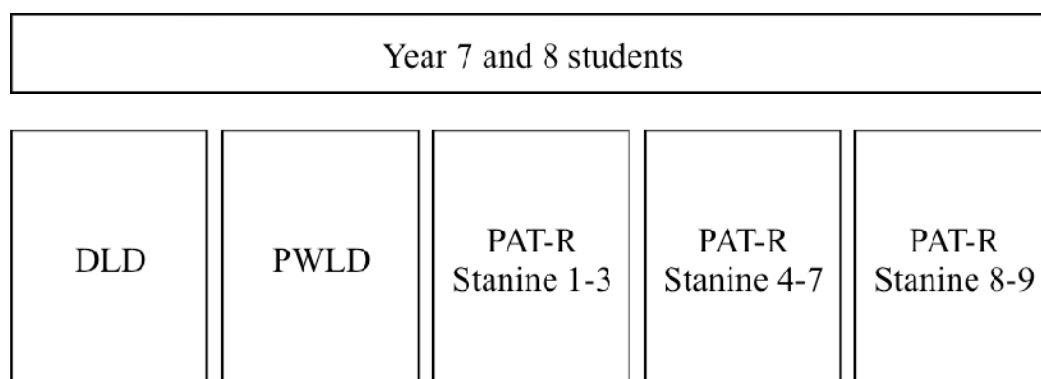


Figure 3.1. Grouping of students.

Participants attended secondary schools in metropolitan Victoria. A total of 400 students were invited to participate in the research project. 179 students completed the Science Vocabulary Survey, with 179 students completing both the attitude survey and vocabulary survey (82 females and 97 males). Of these 179 students, 20 students (11%) presented with a language learning disability. This is representative of the prevalence found in the greater population (10 – 16%) (Bargerhuff et al., 2005; McLeod & McKinnon, 2007). A small group of students was used to trial the candidate-generated vocabulary survey. From the feedback obtained, no changes were deemed necessary to the content or the online versions.

3.6 INSTRUMENTATION

3.6.1 Progressive Achievement-tests – Reading (PAT-R)

The PAT-R was chosen as the assessment tool for grouping students who do not present with a language learning disability. It is widely used by schools in Australia, as it provides Australian norms, is easy to administer and can be computer scored – meaning that teachers involved in the project had minimal time pressures placed on

them. It is a standardised test which has been shown to be a reliable predictor of future academic progress (Fogarty, 2007).

As discussed in Chapter 2 (Section 2.11, p. 46), numerous studies have shown the PAT-R to be a reliable and valid tool. On this basis, the PAT-R was able to be chosen with confidence to assess reading comprehension levels of students who did not present with a language learning disability.

3.6.2 The Ten-Item Attitude Scale

The Ten-Item Attitude Scale (Henderson et al., 2000), an attitude scale which focuses on attitude to class and self-efficacy, was selected (see Table 3.1).

Table 3.1
Attitude Scale Items

Statement
I look forward to science lessons.
Science lessons are fun.
I enjoy the activities we do in science.
I find it easy to understand the words used in science.
I want to find out more about the world in which we live.
Finding out about new things is important.
I enjoy science lessons in this class.
I like talking to my friends about what we do in science.
We should have more science lessons each week.
I feel satisfied after a science lesson.

Information collected from this scale was used to determine different levels of satisfaction with Science. This tool was selected as it has proven reliability in numerous studies, as discussed in Chapter 2 (Section 2.11, p. 46). See Appendix F for the version of the Ten-Item Attitude Scale given to students.

3.6.3 Science Vocabulary Survey

The candidate required an assessment tool to investigate differences in understanding of concrete, instructional and conceptual vocabulary. Initial contact was made with the Australian Council for Educational Research (ACER) to determine whether or not a science vocabulary test with Australian norms existed. At the time of the inquiry, ACER was developing PAT-Science. The candidate was allowed to view a draft copy of the test to establish whether or not it would be suitable. Whilst the test examined students' understandings of science concepts and vocabulary, it did not examine understanding of different types of science vocabulary. The candidate continued to attempt to source a suitable science vocabulary assessment, without success. There were many sources of vocabulary lists, including a comprehensive list of science vocabulary in *Building Academic Vocabulary* (Marzano & Pickering, 2005), however, there was no assessment which investigated different types of science vocabulary.

As a suitable secondary science vocabulary test was not found, the candidate generated an online science vocabulary survey. In order to determine the vocabulary to be included in each section, a variety of resources were used including discussions with science teachers, university supervisor, glossaries from student text books used in Victoria, perusal of science assessments (for instructional vocabulary) and curriculum documents. The candidate's university supervisor and several science teachers validated the Science Vocabulary Survey. They were given a draft copy and asked to comment on the content, instructions and layout. A draft version of the Science Vocabulary Survey was also given to a small group of students for their feedback.

The concrete vocabulary list included the most commonly used equipment in year 7 and 8 classrooms (see Table 3.2). Clear photographs were sourced to provide students with unambiguous pictures of science equipment. (See Appendix G for the student version with accompanying photographs.)

Table 3.2
Concrete Science Vocabulary Items in Science Vocabulary Survey
 Concrete Science Vocabulary (VC)

1. Pipette
2. Petri dish
3. Test tube
4. Beaker
5. Flask
6. Microscope
7. Graduated cylinder
8. Slide
9. Balance
10. Stopper
11. Thermometer
12. Bunsen Burner

Instructional vocabulary was sourced from assessment tasks, school tests and science text books. General instructional vocabulary checklists were also reviewed. The most commonly used instructional vocabulary was included in the vocabulary survey (see Table 3.3). (See Appendix G for the student version with instructions and definition options.)

The selection of conceptual vocabulary was considerably more difficult than the selection of instructional and concrete vocabulary. This was due to the huge number of conceptual words year 7 and 8 students are potentially exposed to during two years of general science studies. The candidate divided conceptual vocabulary into four areas: biological sciences, chemical sciences, earth and space sciences and physical sciences, based on science curriculum documents. Several vocabulary items were selected for each area based on their exposure in year 7 and 8 science courses and texts (see Table 3.4). (See Appendix G for the student version with instructions and definition options.)

Table 3.3
Instructional Science Vocabulary Items in Science Vocabulary Survey

Instructional Science Vocabulary (VI)
1. Analyse
2. Explain
3. Summarise
4. Observe
5. Explore
6. Compare
7. Discuss
8. Design
9. Question
10. Gather

Table 3.4
Conceptual Science Vocabulary Items in Science Vocabulary Survey

Conceptual Science Vocabulary
1. Ecosystem
2. Element
3. Condensation
4. Cell
5. Force
6. Galaxy
7. Adaptation
8. Reaction
9. Revolve
10. Organ
11. Compound
12. Weathering
13. Atmosphere

The candidate-generated Science Vocabulary Survey consisted of three sections, each with multiple-choice answers. (See Appendix G for the complete online version of the Science Vocabulary Survey.) Section one consisted of concrete vocabulary.

Students were presented with four different photographs of science equipment. They were asked to ‘select the picture which matches the word: (target word)’. Students clicked on the number next to the photograph which matched the target word. There were a total of 12 concrete words.

Section two consisted of 10 instructional words. Students were asked to ‘click on the best definition for each word’. Each word had three possible definitions.

Section three consisted of 13 conceptual words. Students were also asked to ‘click on the best definition for each word’. Each word had three possible definitions.

Online versions of the Ten-Item Attitude Scale and the Science Vocabulary Survey were used for a number of reasons. The digital version allowed the researcher to use high quality colour photographs of the concrete vocabulary, which would have been expensive if a paper version had been created. The photographs were also clearer and visually more engaging. Schools were provided with a link to the survey which made access simple for the students. The online surveys were easier to manage in terms of data collection.

3.7 DATA COLLECTION AND ANALYSIS

Quantitative data were collected in the form of PAT-R results, an attitude scale, and science vocabulary test responses. Biographical data were collected in terms of gender, year-level and presence or absence of a language learning disability. PAT-R results were used to group students who did not present with a language learning disability. Quantitative data from the science vocabulary test were used to look at overall test scores across different student groups, as well as test scores for instructional, conceptual and concrete vocabulary groups; and individual vocabulary items. Quantitative data from the attitude scale were used to compare different groups’ understanding of science vocabulary as well as relationships between understanding of different types of science vocabulary and attitude to science.

3.7.1 Procedure and Instruments

Initially, the candidate made personal contact with potential schools. Schools indicating a willingness to become involved in the research project were provided with information sessions for the staff involved. Students and their parents were provided with information sheets as well as consent forms. Parents completed consent forms agreeing to their child's participation in the study. Students also completed consent forms agreeing to their own participation in the study. (See Section 3.9.1 *Informed Consent*, p. 65, and Appendices C and D for information about the consent forms.) Only students who returned both signed consent forms participated in the research.

Each student was provided with a student identification number. This ensured anonymity and enabled Science Vocabulary Survey and Attitude Scale results to be compared. They were also provided with a student code, to allocate them to a specific group as outlined in Section 3.5.1 *Method of Selection and Target population* (p. 51) in this chapter. Students at the participating schools completed the PAT-R as part of their school's routine assessment processes. This information was used to assign grouping codes.

Once students were assigned a student identification number and a student code, they completed the Ten-Point Attitude Scale and Vocabulary Survey.

3.7.2 Administration

Students were provided with a computer link to the Ten-Point Attitude Scale and Science Vocabulary Survey, which were both completed online. The Attitude Scale was completed first as it was the quickest and it was important that the Science Vocabulary Survey did not influence students' responses on the Attitude Scale. These assessments were completed in one session, with most students taking between 20 – 30 minutes to complete the two tasks.

Supervising teachers were required to make sure students entered the correct student identification number and student code. As the assessments were online, they did not need to collect any paperwork.

Information from the online surveys was automatically collated in an Excel Spreadsheet. This reduced the amount of time which would have been spent marking the students' responses and inputting data.

3.7.3 Analysis

In considering the data presented to be analysed, the following methods of data interpretation were used: descriptive statistics (means and standard deviations), simple correlations (Pearson correlations test), *t-tests*, analysis of variance, post hoc tests and effect size (see Table 3.5). Descriptive analysis was used to analyse mean scores on the Attitude Scale and the three Science Vocabulary Survey scales. Simple correlations were used to investigate correlations between attitude to science and comprehension of science specific vocabulary. *T-tests*, analysis of variance and post hoc tests were used to analyse differences in comprehension between different types of vocabulary, between different student groups. *T-tests* and effect size were also used to investigate differences in science vocabulary knowledge between students with a diagnosed language learning disability (or presenting with one) and students without a diagnosed language learning disability. Examination of responses to individual items provided percentages of correct and incorrect responses on the Science Vocabulary Survey, and percentages for levels of satisfaction on the Attitude Scale.

Table 3.5
Overview of Data Collection and Interpretation

Research Question	Method of data collection	Method of data interpretation
1. What are the mean scores of the whole sample on the Attitude Scale and the Science Vocabulary Survey?	Attitude Scale Science Vocabulary Survey	Means and standard deviations on Attitude Scale and Science Vocabulary Survey scales.
2. Are there associations between Science Vocabulary Survey Scales?	Science Vocabulary Survey	Simple correlations between scales of the Science Vocabulary Survey (Pearson correlation test)
3. Are there associations between attitude to science and comprehension of science specific vocabulary?	Attitude Scale Science Vocabulary Survey	Simple correlations between scales of Science Vocabulary Survey and Attitude Scale (Pearson correlation test)
4. Are there differences in the comprehension of various types of science vocabulary, i.e. concrete, instructional and conceptual, between different student groups?	PAT-R Science Vocabulary Survey	t-tests for different samples Oneway ANOVA with group membership as main effect and post hoc tests
5. Are there differences in science vocabulary knowledge between students with a diagnosed language learning disability (diagnosed or undiagnosed) and students without a diagnosed learning disability?	PAT-R Science Vocabulary Survey	t-tests and Effect size for different groups
6. What are students' responses to individual items on the Attitude Scale and the Science Vocabulary Survey?	Attitude Scale Science Vocabulary Survey	Examinations of students' responses to individual items on the Attitude Scale and the Science Vocabulary Survey

Data analysis included:

- comparison of comprehension of science specific vocabulary across groups
- correlation between scores on the Attitude Scale and Science Vocabulary Survey
- comparison of scores on the Attitude Scale and different groups
- analysis of PAT-R test scores
- comparison of comprehension of types of vocabulary across groups (e.g. instructional and conceptual vocabulary)
- analysis of responses to individual items on the Attitude Scale and Science Vocabulary Survey
- comparison of mean scores on the Attitude Scale and Science Vocabulary Survey

Analysis of the PAT-R results was completed first in order to determine the groupings of students with no language learning disability. The Ten-Point Attitude Scale was then completed with the Science Vocabulary Survey completed last. Mean analysis of scores on both the Attitude Scale and Science Vocabulary Survey was used for the whole sample. The results are discussed in Chapter 4, Section 4.2 (p. 69).

Simple correlations were used to analyse data from the Attitude Scale and Science Vocabulary Survey and to determine associations between attitude to science and comprehension of science specific vocabulary. The results are shared and analysed in Chapter 4, Section 4.3 (p. 71).

T-tests were used to determine year-level and gender differences on the Attitude Scale and Science Vocabulary Survey Scales. Oneway ANOVA and post hoc tests were used to determine differences between groups in the Attitude Scale and Science Vocabulary Survey Scales. The results of these analyses are presented and discussed in Chapter 4, Section 4.4 (p. 72).

A *t-test* data analysis was used to investigate differences in science vocabulary knowledge between students with a language learning disability (diagnosed or

undiagnosed) and students without a language learning disability. Correlations were made between vocabulary types (instructional, conceptual, concrete), groupings (diagnosed language learning disability, presenting with a language learning disability – not diagnosed, and PAT-R groupings) and Attitude Scale results. Effect size was also used to determine the significance, if any, for membership of the different groups. The results are presented and analysed in Chapter 4, Section 4.5 (p. 73).

Students' responses to individual items on the Attitude Scale and the Science Vocabulary Scale were examined. The Science Vocabulary Scale items were analysed to determine error patterns for each item, investigate the percentage of inaccurate responses provided by students with language learning disabilities, and the percentage of students with language learning disabilities providing incorrect responses for each item. The Attitude Scale statements were analysed to identify the level of positivity or negativity for each item. The results and analysis of this data are presented in Chapter 4, Section 4.6 (p. 79).

3.8 ASSUMPTIONS AND LIMITATIONS

A couple of outliers were noticed - students with high PAT-R scores whose answers on the vocabulary test were almost completely wrong. These outliers were removed from the results, however this small number of outliers made little difference to the final results.

There was a limited sample in terms of size and source. Four hundred students were invited to participate but less than half returned their completed consent forms. The need for active consent reduced the likelihood of a high percentage return rate, although a 45% strike rate is considered above average. The sample size and location of the schools were convenient for the candidate, however it would be worthwhile to repeat the research with a larger sample and more diverse range of schools.

3.9 ETHICAL CONSIDERATIONS

3.9.1 Informed Consent

Following formal approval by the Curtin University Ethics Committee of the research project (Appendix H), participants were sought from secondary schools. After initial agreement by schools to participate in the research project, parents were sent Information Sheets and Consent Forms for both parent(s) and student(s) to sign (Appendices D and E). As well as providing student information sheets, to make sure the information was accessible to them as well as their parents, the purpose of the research was explained to the students at an information session. Parents and students were provided with contact details to allow them to ask further questions of the researcher. Staff involved in the data collection process were also provided with opportunities for clarification.

3.9.2 Anonymity

Participants and schools were coded to ensure anonymity. Participants and schools will not be identified in the thesis or any publications or disseminations of the research findings.

3.9.3 Confidentiality

The right to confidentiality was respected at all times for participants and schools. Participants and schools were coded to ensure anonymity. Only the candidate had access to the codes to ensure confidentiality was maintained. Participants and schools were not identified in the thesis or any publications or disseminations of the research findings.

3.9.4 Consideration

Participant involvement in the research project did not result in undue time pressures. Completion of the PAT-R takes 40 minutes, however the schools involved already administered this test as part of year 7 baseline assessments. Completion of the

Attitude Scale and Science Vocabulary Survey for students took 20 - 30 minutes for all the students involved.

3.10 Summary

Male and female students in Years 7 and 8 were asked to participate in the research project. An overview of the research process is outlined in Figure 3.2. Once informed consent was received, students were grouped and coded according to their level of reading comprehension, or whether they had a diagnosed, or undiagnosed language learning disability. Students completed an Attitude Scale and Science Vocabulary Survey online. The collated data were analysed in a number of different ways, in order to answer the six research questions posed at the start of the research:

1. What are the mean scores of the whole sample on the Attitude Scale and the Science Vocabulary Survey?
2. Are there associations between Science Vocabulary Survey scales?
3. Is there a correlation between attitude to science and comprehension of science specific vocabulary?
4. Are there differences in the comprehension of various types of science vocabulary, i.e. concrete, instructional and conceptual, between different student groups?
5. Are there differences in science vocabulary knowledge between students with a language learning disability (diagnosed or undiagnosed) and students without a diagnosed learning disability?
6. What are students' responses to individual items on the Attitude Scale and the Science Vocabulary Survey?

Selection of schools					
Parents and students provided with information sheets and consent forms					
Consent forms signed by parents and students					
Students with a language learning difficulty allocated one of the following codes DLD - diagnosed learning difficulty PWLD - presenting with a learning difficulty (not formally diagnosed)					
Students without a language learning difficulty complete PAT-R					
Students grouped according to PAT-R scores and allocated a code: PR13 - Stanine 1 - 3 PR47 - Stanine 4 - 7 PR89 - Stanine 8 - 9					
Students complete Attitude Scale					
Students complete Science Vocabulary Survey					
Results collated in a data base					
Data analysed					
Means and standard deviations	Simple correlations	Simple correlations	<i>t</i> tests, Oneway ANOVA, post hoc tests	<i>t</i> tests and Effect Size	Examination of responses to individual items
Mean scores of whole sample for Attitude Scale and Science Vocabulary Survey	Correlation between scales of Science Vocabulary Survey	Correlation between attitude to science and comprehension of science specific vocabulary	Differences in comprehension of various types of vocabulary (concrete, instructional, conceptual) between different student groups	Differences in science vocabulary knowledge between students with a language learning disability (diagnosed or undiagnosed) and students without a language learning disability?	Patterns in student responses to individual items on the Attitude Scale and Science Vocabulary Survey

Figure 3.2. Outline of research process.

A number of different methods of data collection were used to collect quantitative data. A commercial diagnostic reading assessment (PAT-R) was used to group students. Two surveys, an Attitude Scale and candidate-generated Science Vocabulary Survey, were used to collect data to determine levels of understanding of different types of science vocabulary and attitudes to science.

Data were analysed using a number of different statistical tools. These are outlined in Table 3.5.

Chapter 3 outlines the methodology used for the collection and analysis of data. Results and analyses of data are presented in detail in Chapter 4. Relationships between and within the data are also discussed in Chapter 4.

CHAPTER 4

RESULTS AND ANALYSIS

4.1. INTRODUCTION

Quantitative data were collected from male and female students in Years 7 and 8 attending two independent schools in Melbourne, Victoria. Data were analysed using a number of different statistical tools which are outlined in the previous chapter.

Results and analyses of the data relating to each research question are presented in Chapter 4. This includes discussion of the relationships between and within the data. Each research question is outlined and the relevant results presented and discussed.

4.2 MEAN SCORES FOR THE ATTITUDE SCALE AND SCIENCE VOCABULARY SURVEY

This section presents the results of data analysis relating to research question 1:

What are the mean scores of the whole sample on the Attitude Scale and the Science Vocabulary Survey?

Descriptive analysis was used to determine the whole sample of students' mean scores, and standard deviations, on the Attitude Scale and the Science Vocabulary Survey. Students' responses on the Attitude Scale were scored on a scale of 1 – 3 where 3 was the most positive and 1 the least positive. Table 4.1 shows a mean average item score of 2.30 on the Attitude Scale which indicates a more positive attitude to science overall for the combined year 7 and 8 group of students. Overall, there was a positive response to science for the 179 students who completed the Attitude Survey. Details of the responses to individual statements in the Attitude Scale are discussed in Section 4.6 (p. 79).

Table 4.1
Mean Scores and Standard Deviations for Attitude Scale and Science Vocabulary Survey Scales

	Number of Valid Reponses	Mean	SD
Attitude	179	2.30	.41
Concrete Vocabulary	197	11.80	1.6
Instructional Vocabulary	197	8.60	1.40
Conceptual Vocabulary	197	10.54	2.83

There were 197 responses for each of the Vocabulary Scales, compared with 179 responses to the Attitude Scale. There were more eligible students in this sample, as some students did not include their identification code in the Attitude Scale.

Students were provided with four possible responses for each of the 12 items in the Concrete Science Vocabulary section of the Science Vocabulary Survey. They were presented with one word and four photographs of science equipment. They clicked on the picture which best matched the target word. Students were given a score of 1 for a correct response and 0 for an incorrect response. This task was the only section to include a visual component. It was expected that students would perform better on this section, as pictures are easier to name and remember than text only information. The mean of 11.8 out of a possible score of 12 (98.3%) indicates that most students performed very well on this section. This may be due to familiarity with the equipment and the use of photographs to indicate understanding of a target word, rather than a definition.

Students were provided with three possible responses for each of the 10 items in the Instructional Science Vocabulary section of the Science Vocabulary Survey. They were presented with one word and three possible definitions. They clicked on the definition which best matched the target word. Students were given a score of 1 for a correct response and 0 for an incorrect response. The mean score of 8.60 out of a possible 10 (86%) indicates that most students were able to match the target words

with their definition. They did not perform as well in this section as in the concrete vocabulary section (98.3%), however, the overall correct response level was still high.

As with the Instructional Vocabulary section, students were provided with three possible responses for each of the 13 items in the Conceptual Science Vocabulary section of the Science Vocabulary Survey. They were presented with one word and three possible definitions. They clicked on the definition which best matched the target word. Students were given a score of 1 for a correct response and 0 for an incorrect response. The mean score of 10.54 out of a possible 13 (81.1%) indicates that students found it more difficult to match the definitions for conceptual words. The results for each of the vocabulary scales are discussed in more detail in Section 4.6 (p. 79) of this chapter.

In summary, the mean scores indicate that overall there is a positive attitude towards science for the combined Year 7 and 8 students participating in the research project. This in itself is a positive finding as much of the research indicates that students develop a more negative attitude to science as they move from primary to secondary education (Morrell & Lederman, 1998).

The mean scores for each of the vocabulary scales indicate that students found the concrete vocabulary task easiest of the three scales and the conceptual vocabulary task the most difficult. These results confirm the anecdotal observations made by the candidate over a number of years.

4.3 ASSOCIATIONS BETWEEN SCIENCE VOCABULARY SURVEY SCALES

This section presents the results of data analysis relating to research question 2:

Are there associations between science vocabulary survey scales?

A Pearson correlation analysis was used to determine simple correlations for the whole sample between the three science vocabulary survey scales.

There is a statistically significant association between students' understanding of concrete vocabulary and instructional vocabulary (see Table 4.2). There is a statistically significant association between students' understanding of instructional vocabulary and conceptual vocabulary. There is no statistically significant association between understanding of concrete vocabulary and conceptual vocabulary.

Table 4.2

Intercorrelations between Scales of the Science Vocabulary Survey

Scale	VC	VI	VCN
VC	–	.18*	.04
VI		–	.22**
VCN			–

* $p < 0.05$, ** $p < 0.01$

The sample consisted of 196 students.

4.4 ASSOCIATIONS BETWEEN ATTITUDE TO SCIENCE AND COMPREHENSION OF SCIENCE SPECIFIC VOCABULARY

This section presents the results of data analysis relating to research question 3:

Are there associations between attitude to science and comprehension of science specific vocabulary?

A Pearson correlation analysis was used to determine simple correlations for the whole sample between attitude to science and comprehension of science specific vocabulary. There are significant correlations between students' understanding of instructional vocabulary and their attitude to science, and students' understanding of conceptual vocabulary and their attitude to science (see Table 4.3). There is no significant association between concrete vocabulary and attitude. This indicates students who perform well on the instructional vocabulary task and the conceptual vocabulary task, are likely to have a more positive attitude to science. Conversely,

students who perform poorly on these two vocabulary scales are more likely to have a less positive attitude to science.

Table 4.3

Simple Correlations between Scales of the Science Vocabulary Survey and Attitude

Scale	Attitude
VC	.10
VI	.20**
VCN	.15*

* $p < 0.05$, ** $p < 0.01$

The sample consisted of 179 students.

In summary, the data indicate that understanding of instructional and conceptual vocabulary has a significant association with attitude to science. The implications are that targeting direct instruction of instructional and conceptual vocabulary should lead to a more positive attitude to science. Targeting concrete vocabulary is less likely to have an impact on a student's attitude to science.

4.5 DIFFERENCES IN THE ATTITUDES AND COMPREHENSION OF VARIOUS TYPES OF SCIENCE VOCABULARY BETWEEN DIFFERENT STUDENT GROUPS

This section presents the results of data analysis relating to research question 4:

Are there differences in the attitudes and comprehension of various types of science vocabulary, that is, concrete, instructional and conceptual, between different student groups?

4.5.1 Gender differences

Descriptive analysis was used to find the mean scores and standard deviations on the Attitude Scale and the three Science Vocabulary Survey scales for the whole sample of male students and the whole sample of female students. A *t-test* for separate samples provided information about any significant gender differences for the Attitude Scale and the Science Vocabulary Survey Scales (see Table 4.4).

Table 4.4
Differences in Means and Standard Deviation for Males and Females in Attitude and Science Vocabulary Survey Scales

Scales	N		M		SD		Diff.	<i>t</i>
	M	F	M	F	M	F		
Attitude	97	82	2.42	2.17	.36	.43	.25	4.30*
VC	110	87	11.75	11.87	1.49	1.73	.12	.55
VI	110	87	8.67	8.51	1.10	1.70	.16	.74*
VCN	110	87	10.84	10.17	2.02	3.58	.67	1.55

* $p < 0.05$

There are significant differences between males and females in attitude to science and understanding of instructional vocabulary. Year 7 and 8 males as a group have a more positive attitude to science. They also have a greater understanding of instructional vocabulary. This may have an impact on their ability to answer questions under test conditions as well as complete tasks accurately. Teachers in coeducational classes in particular need to be aware of the differences in both attitude and understanding of instructional vocabulary in order to increase girls' attitudes to science and their engagement in science. There are no significant differences in understanding of concrete or conceptual vocabulary. Overall, males have a more positive attitude to science than females, which supports the research into this area (Simpson & Oliver, 1985; Speering & Rennie, 1996), although previous research shows that females have more positive perceptions of teacher-student interpersonal behaviours (Eccles, 2006). It should be noted that females in the research project still had a positive attitude to science, which is different to the findings of Morrell and Lederman (1998) who found that girls perceive science negatively.

4.5.2 Year-level differences

Descriptive analysis was used to find the mean scores and standard deviations on the Attitude Scale and the three Science Vocabulary Survey scales for the whole sample of Year 7 students and Year 8 students. Information from *t-test* for separate samples was used to determine if significant year-level differences existed for the Attitude Scale and the Science Vocabulary Survey Scales (see Table 4.5).

Table 4.5

Differences in Means and Standard Deviation for Students in Year 7 and Year 8 in Attitude and Science Vocabulary Survey Scales

Scales	N		Mean		SD		Diff.	t
	Year 7	Year 8	Year 7	Year 8	Year 7	Year 8		
Attitude	117	62	2.29	2.32	.42	.41	.03	.30
VC	124	73	11.69	11.99	1.47	1.79	.30	1.18
VI	124	73	8.65	8.53	1.57	1.06	.12	.60
VCN	124	73	10.23	11.08	3.15	2.08	.85	2.29

No differences were found between Year 7 students and Year 8 students on the Attitude Scale or the Science Vocabulary Survey Scales. According to previous research (Morrell & Lederman, 1998) a decline in attitude would be expected. These data suggest that the students in this study are being well supported, as their overall positive attitude to science is being maintained.

4.5.3 Group differences

Students taking part in the research were allocated to one of five groups:

DLD – Diagnosed Learning Disability

PWLD – Presenting with a Learning Disability (not formally diagnosed)

PR13 – Stanine score of 1-3 on the PAT-R (reading comprehension test)

PR47 – Stanine score of 4-7 on the PAT-R

PR89 – Stanine score of 8-9 on the PAT-R

Research Question 4 investigated differences between these groups for the Attitude Scale and Science Vocabulary Survey Scales. Analysis of variance (ANOVA) was used, rather than *t-test*, as there were more than two groups to compare. Results may become unreliable if *t-test* is used with more than two samples (Choudhury, 2009). ANOVA creates an F value, which indicates group membership as the main effect.

Table 4.6

<i>Differences between Groups in Attitude and Science Vocabulary Survey Scales</i>						
Group	N	M	SD	F value	Sig.	Post hoc result
Attitude				4.76	.001	PR47>DLD (p<0.05)
DLD	13	1.98	.44			PR89>DLD (p<0.01)
PWLD	7	1.91	.40			PR89>PWLD (p<0.05)
PR13	6	2.28	.47			
PR47	99	2.32	.40			
PR89	54	2.41	.36			
VC				4.15	0.003	PR13>DLD (p<0.05)
DLD	13	10.69	1.55			PR13>PWLD (p<0.05)
PWLD	7	10.43	2.51			
PR13	6	13.00	3.46			
PR47	111	11.87	1.37			
PR89	60	11.95	1.47			
VI				5.83	0.000	PR47>DLD (p<0.01)
DLD	13	7.31	2.46			PR89>DLD (p<0.01)
PWLD	7	7.43	3.10			PR89>PWLD (p<0.01)
PR13	6	8.00	3.29			
PR47	111	8.95	1.01			
PR89	60	8.60	.87			
VCN				10.43	0.000	PR47>DLD (p<0.05)
DLD	13	8.23	2.83			PR89>DLD (p<0.01)
PWLD	7	8.43	2.37			PR89>PWLD (p<0.05)
PR13	6	6.00	1.90			PR47>PR13 (p<0.01)
PR47	111	10.69	3.02			PR89>PR13 (p<0.01)
PR89	60	11.48	1.55			

Note: On the attitude scale, 1 = disagree, 2 = not sure, 3 = agree
 On the Science Vocabulary Scale, 1 = right and 0 = wrong.

The F value was significant for all scales, therefore post hoc tests were used to show the significance of specific groups. This information is recorded in Table 4.6.

F values shown in Table 4.6 show there are significant differences between the groups on all four scales: attitude and understanding of the three different types of science vocabulary. This implies that group membership is associated with attitude

level and understanding of science vocabulary. Post hoc tests then reveal how membership of specific groups is associated with each of the four scales – Attitude, Concrete Vocabulary, Instructional Vocabulary and Conceptual Vocabulary.

4.5.3.1. Group differences on the Attitude Scale

Results of post hoc tests revealed significant differences for specific groups in relation to attitude to science. Students in the PR47 and PR89 groups (average to above average reading comprehension levels) have a more positive attitude to science than students with a diagnosed language learning disability. Students in the PR89 group (above average reading skills) also have a more positive attitude to science than students presenting with an undiagnosed language learning disability (PWLD). There is no significant difference in relation to attitude, between students grouped according to their reading comprehension levels. The presence of a language learning disability (diagnosed or undiagnosed) has a clear impact on a student's attitude to science. This is supported by research into attitude to school in general for this group of students (Eadie et al., 2010).

4.5.3.2. Group differences on the Concrete Vocabulary Scale

Results of post hoc tests revealed significant differences for specific groups in relation to understanding of concrete science vocabulary. Students in the PR13 group (below average reading comprehension skills) performed significantly better on the concrete vocabulary task than students in the DLD and PWLD groups (students with a language learning disability – diagnosed or undiagnosed). There was no significant difference between the different reading comprehension groups. Neither was there any significant difference between the PR47 and PR89 groups (average to above average reading comprehension levels) and the DLD and PWLD groups.

4.5.3.3. Group differences on the Instructional Vocabulary Scale

Results of post hoc tests revealed significant differences for specific groups in relation to understanding of instructional science vocabulary. Students in the PR47 group (average reading comprehension) performed significantly better on the

instructional vocabulary task than students in the DLD group. Students in the PR89 group (above average reading comprehension) performed significantly better than students in the DLD and PWLD groups. There was no significant difference between the groups organised according to reading comprehension levels.

4.5.3.4. Group differences on the Conceptual Vocabulary Scale

Results of post hoc tests revealed significant differences for specific groups in relation to understanding of conceptual science vocabulary. The PR47 group (average reading comprehension level) did significantly better than the DLD and PR13 groups. The PR89 group did significantly better than the DLD, PWLD and PR13 groups. There was no significant difference between the average and above average readers. There was no significant difference between the poor readers, or students with a diagnosed/undiagnosed language learning disability.

In summary, students with a language learning disability, diagnosed or undiagnosed, perform at a significantly lower level on all scales of the Science Vocabulary Survey and have a less positive attitude to science. Students with average to above average reading comprehension skills enjoy science more than students with diagnosed language learning disabilities. The lack of differences between groups organised according to reading comprehension levels suggests that reading comprehension skills alone do not predict a student's ability to understand specific science vocabulary. Rather, it is likely that the underlying language difficulties of the language learning disabled student have a significant impact on their ability to understand science vocabulary.

4.6 DIFFERENCES IN SCIENCE VOCABULARY KNOWLEDGE BETWEEN STUDENTS WITH A LEARNING DISABILITY (DIAGNOSED OR UNDIAGNOSED) AND STUDENTS WITHOUT A LEARNING DISABILITY

This section presents the results of data analysis relating to research question 5:

Are there differences in science vocabulary knowledge between students with a learning disability (diagnosed or undiagnosed) and students without a learning disability?

A *t-test* was used to determine whether or not there were differences in science vocabulary knowledge between students with a language learning disability (diagnosed or undiagnosed) and students without a language learning disability (see Table 4.7). Effect sizes were calculated to determine the magnitude of group membership and therefore the educational implications.

There were significant differences for all Attitude Scale means and all Vocabulary Scales. Membership of a particular group has a very high significance on both attitude and understanding of science vocabulary.

The effect size results reveal that group membership has a significant effect on Attitude and Science Vocabulary Survey Scales. Effect size interpretations were based on Cohen's (1977) operational definitions of small effect size (0.2), medium effect size (0.5) and large effect size (0.8). Using these definitions, it can be clearly stated that membership of the group of students with a language learning disability (diagnosed or not) has a medium effect on understanding of concrete and instructional vocabulary. Membership of this same group of students has a large effect on attitude to science and understanding of conceptual vocabulary.

The implication of these results is that students with a diagnosed language learning disability or presenting with language learning disability are at risk of a less positive attitude to science than their peers, and are likely to experience difficulties understanding all types of science vocabulary, especially conceptual vocabulary.

Table 4.7

Differences in Means and Standard Deviation for Students with a Language Learning Disability and Students without a Language Learning Disability

	N	Mean	Standard Deviation	<i>t</i>	Effect size
Attitude				3.94**	.94
(1) DLD+PWLD	20	1.96	.42		
(2) PR13+PR47+PR89	159	2.35	.39		
VC				2.09*	.61
(1) DLD+PWLD	20	10.60	.16		
(2) PR13+PR47+PR89	177	11.49	.06		
VI				2.48*	.76
(1) DLD+PWLD	20	7.45	.25		
(2) PR13+PR47+PR89	177	8.88	.11		
VCN				7.51***	1.61
(1) DLD+PWLD	20	7.30	.13		
(2) PR13+PR47+PR89	177	10.25	.15		

4.7 STUDENTS' RESPONSES TO INDIVIDUAL ITEMS ON THE ATTITUDE SCALE AND SCIENCE VOCABULARY SURVEY.

This section presents the results of data analysis relating to research question 6:

What are students' responses to individual items on the Attitude Scale and Science Vocabulary Survey?

Individual items were analysed according to percentage correct, percentage incorrect, the percentage of errors made by students in the DLD or PWLD groups, and the percentage of students with a language learning disability who gave an incorrect response to the item. The three different vocabulary scales were analysed (see Table 4.8).

4.7.1 Science Vocabulary Survey Scales

The Science Vocabulary Survey consists of three scales: concrete, instructional and conceptual vocabulary. Student responses for each of the items on each of the scales are presented and discussed in the following sections.

4.7.1.1 Conceptual Vocabulary Scale

The mean average for the entire Concrete Vocabulary Scale was 98.5% (see Section 4.2 in this chapter), indicating that most students connected most of the target words with its corresponding photograph. Table 4.8 presents a breakdown of responses to individual items. The high level of correct responses indicates most students are familiar with the terms for equipment used within practical science lessons.

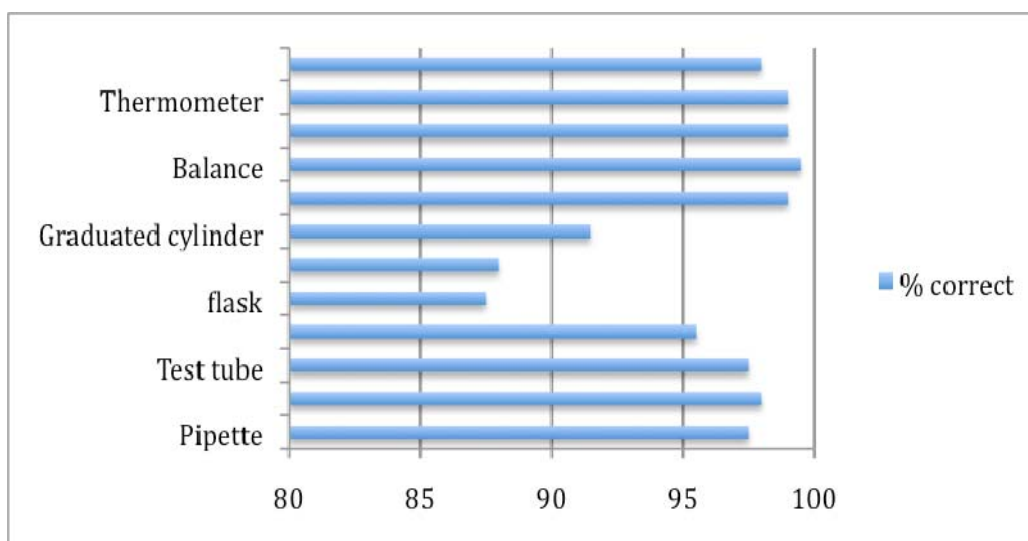


Figure 4.1. Percentage of correct responses to concrete vocabulary items.

Table 4.8

Student Responses to Conceptual Vocabulary Scale

Word	N	% correct	% incorrect	% of errors made by students with DLD/PWLD	% of students with DLD/PWLD making errors
Pipette	197	97.5	2.5	60.0	10.0
Petri dish	197	98.0	2.0	75.0	10.0
Test tube	197	97.5	2.5	60.0	15.0
Beaker	197	95.5	4.5	14.0	5.0
flask	197	87.5	12.5	15.0	20.0
microscope	197	88.0	12.0	30.0	40.0
Graduated cylinder	197	91.5	8.5	19.0	20.0
Slide	197	99.0	1.0	0	0
Balance	197	99.5	0.5	0	0
stopper	197	99.0	1.0	50.0	50.0
Thermometer	197	99.0	1.0	50.0	5.0
Bunsen burner	197	98.0	2.0	40.0	10.0

The three items which students experienced the most difficulties with were ‘graduated cylinder’, ‘microscope’ and ‘flask’ (see Figures 4.1 and 4.2). ‘Graduated cylinder’ was incorrectly identified as ‘flask’ by 7% of students and ‘test tube’ by 1.5%. These errors could be considered semantic in nature, as the alternatives were all glass containers. ‘Flask’ was incorrectly identified as ‘graduated cylinder’ by 8% of students, ‘beaker’ by 4% and test tube by 0.5%. Again, these errors were each likely to be semantic errors as the options were all glass containers. ‘Microscope’ was misidentified by 40% of students with a language learning disability (see Figure 4.4). All incorrect responses linked the photograph of the telescope with the word ‘microscope’. This error may be a semantic (category) error or a phonological (sound storage) error. This type of error is not unusual for a student with a language learning disability.

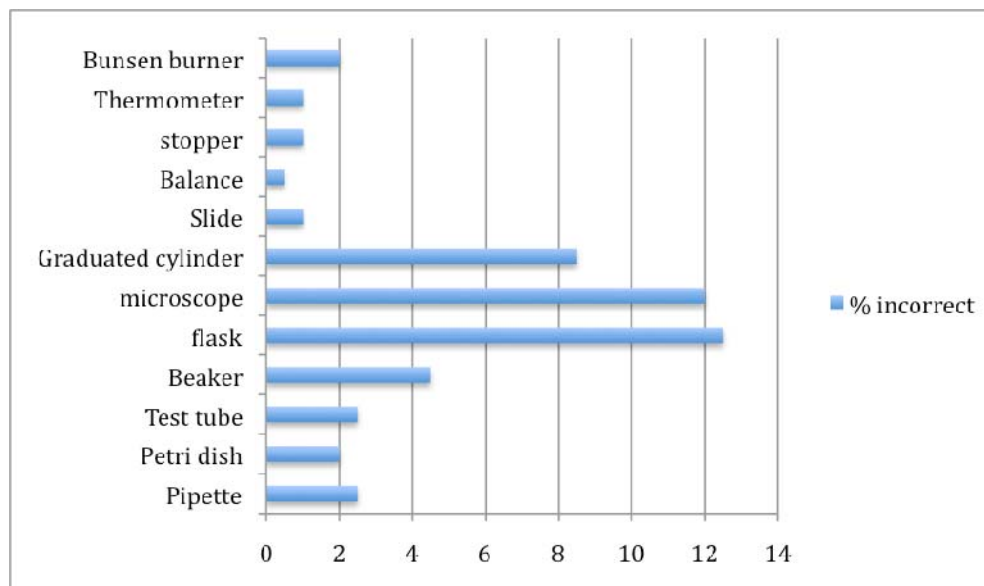


Figure 4.2. Percentage of incorrect responses to concrete vocabulary items.

Overall, there were very few errors made, however students in the DLD/PWLD group were more likely to make an error with an item which had semantically or visually similar alternatives. For example, each of the students who misidentified ‘petri dish’ chose the picture of the balance, which has 2 dishes for weighing, which suggests that they may have focused on the ‘dish’ part of the term ‘petri dish’. Items in which their percentage of errors was less, compared with their peers, (see Figure 4.3) were more likely to include subtle similarities, such as the differences between ‘graduated cylinder’, ‘beaker’ and ‘flask’.

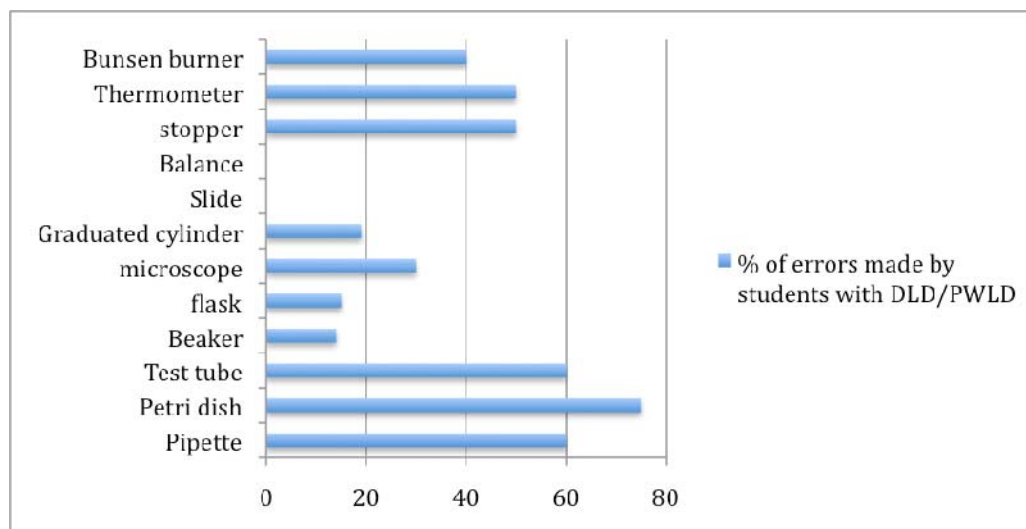


Figure 4.3. Percentage of errors made by DLD/PWLD students.

All of the students with a language learning disability were able to identify ‘balance’ and ‘slide’ (see Figure 4.4). These students had considerable difficulties with terms such as ‘stopper’ and ‘microscope’.

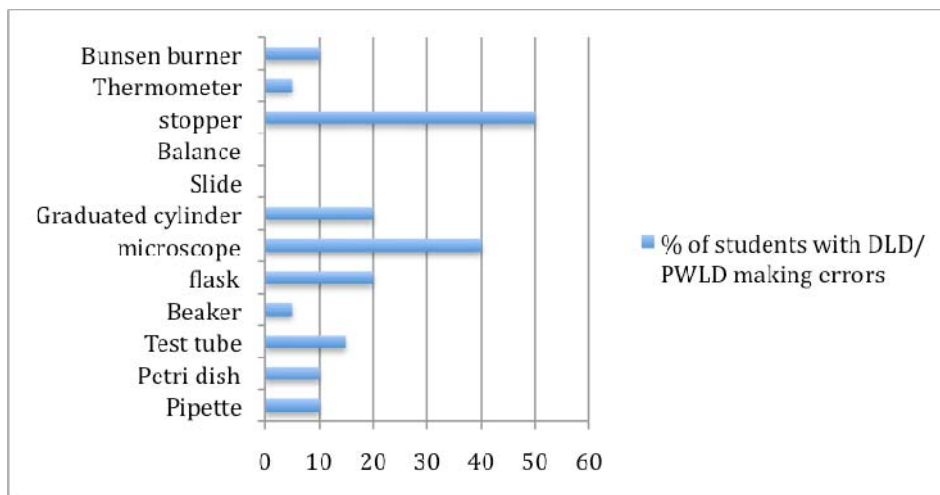


Figure 4.4. Percentage of students with DLD/PWLD making errors.

Most errors made in this section of the Science Vocabulary Scale were made by students in the DLD/PWLD groups. There was a high correct response rate overall, with 87.5% the lowest percentage scored for any of the items in this scale (see Table 4.8).

4.7.1.2 Instructional Vocabulary Scale

The mean average for the entire Instructional Vocabulary Scale was 86% (see Section 4.2 Mean scores for the Attitude Scale and Science Vocabulary Survey, in this chapter), indicating that most students linked an individual item to its definition. Correct responses to items ranged from 58% for ‘observe’ to 98% for ‘question’ (see Table 4.9).

Overall, students experienced the most difficulty with the terms ‘observe’, ‘explain’ and ‘summarise’ (see Figure 4.5 and Figure 4.6).

Table 4.9
Student Responses to Instructional Vocabulary Scale

Word	N	% correct	% incorrect	% of errors made by students with DLD/PWLD	% of students with DLD/PWLD making errors
Analyse	197	79.0	21.0	11.0	25.0
Explain	197	73.0	27.0	11.0	50.0
Summarise	197	96.0	4.0	33.0	15.0
Observe	197	58.0	42.0	9.0	40.0
Explore	197	96.0	4.0	33.0	15.0
Compare	197	97.0	3.0	50.0	20.0
Discuss	197	91.0	9.0	50.0	20.0
Design	197	95.0	5.0	33.0	20.0
Question	197	98.0	2.0	33.0	10.0
Gather	197	93.0	7.0	47.0	35.0

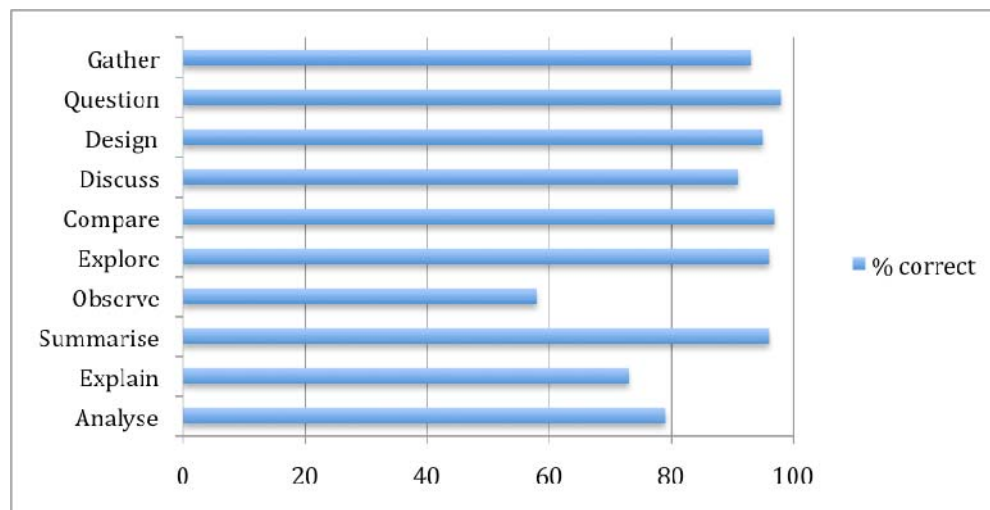


Figure 4.5. Percentage of correct responses to Instructional Vocabulary items.

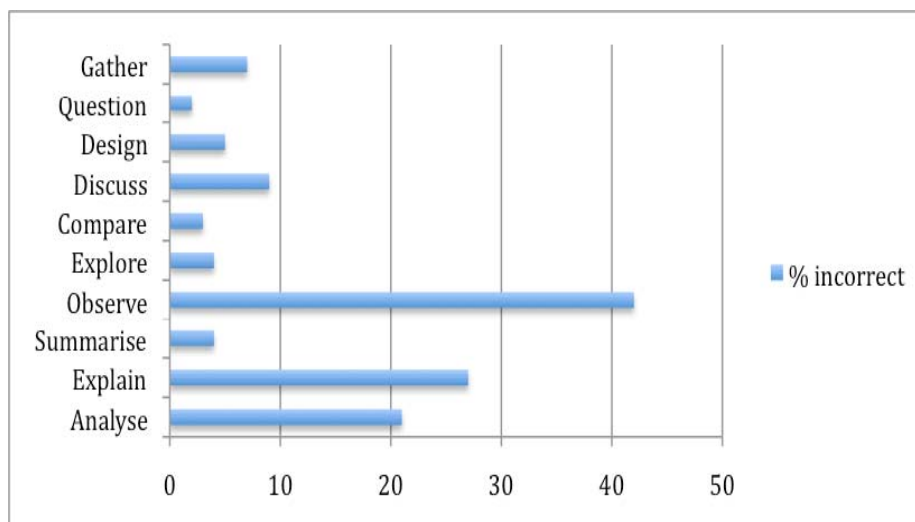


Figure 4.6. Percentage incorrect responses to instructional vocabulary items.

While students with language learning disabilities responded incorrectly to each of these three terms, they also experienced difficulties with more basic terms such as ‘gather’, ‘discuss’ and ‘compare’ (see Figure 4.7). Half of this group of students were not able to correctly identify the meaning of ‘compare’ or ‘discuss’. These are key terms for scientific investigation and discussion. If students are unsure of the meaning of these terms, then it is anticipated that they will struggle to engage in a range of classroom and home-based tasks.

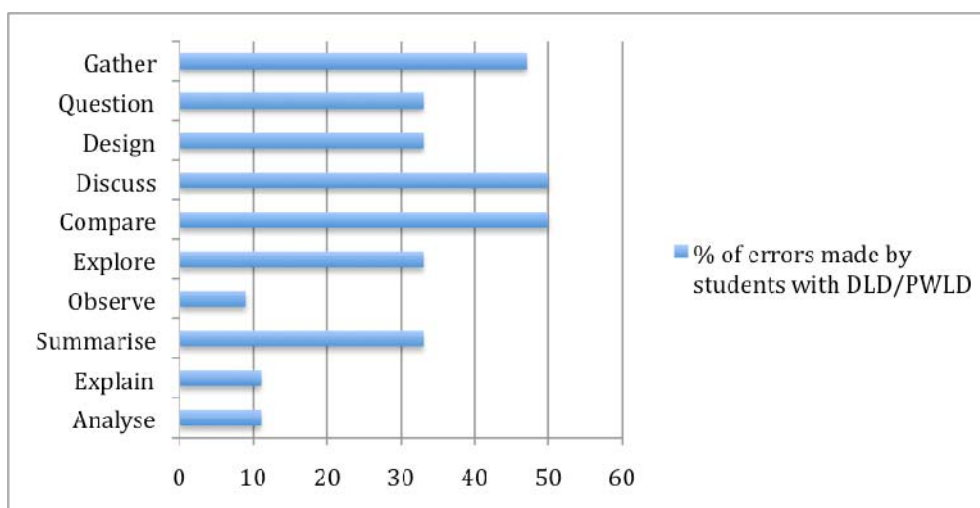


Figure 4.7. Percentage of errors made by DLD/PWLD students.

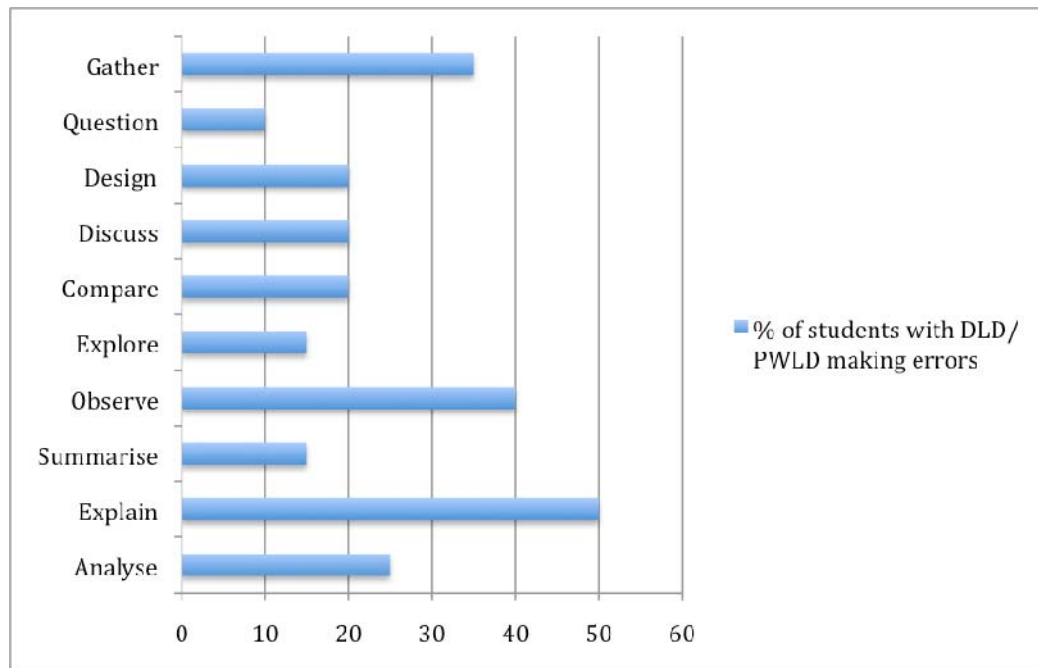


Figure 4.8. Percentage of students with DLD/PWLD making errors.

Students with DLD and PWLD had the most difficulties with words such as explain, observe and gather (see Figure 4.8). These are very common words used in science classrooms and assignments. It is important for teachers to be aware of the difficulties these students may have with these words, and ensure that they have a clear understanding of instructions and assignment tasks.

4.7.1.3 Conceptual Vocabulary Scale

Overall, students found conceptual words more difficult to define. There was a wide range of correct responses across the individual items, with scores ranging from 57% correct for ‘weathering’ and ‘element’ to 96% correct for ‘galaxy’ (see Table 4.10 and Figure 4.9). The percentage of incorrect responses can be clearly seen in Figure 4.10, with its uneven spread of results across the items in the scale.

Table 4.10

Student Responses to Conceptual Vocabulary Scale

Word	N	% correct	% incorrect	% of errors made by students with DLD/PWLD	% of students with DLD/PWLD making errors
Ecosystem	197	89.0	11.0	30.0	35.0
Element	197	57.0	43.0	16.0	70.0
Condensation	197	60.0	40.0	20.0	85.0
Cell	197	85.0	15.0	16.0	25.0
Force	197	82.0	18.0	11.0	20.0
Galaxy	197	96.0	4.0	50.0	10.0
Adaptation	197	90.0	10.0	35.0	35.0
Reaction	197	89.0	11.0	38.0	45.0
Revolve	197	70.0	30.0	13.0	40.0
Organ	197	87.0	13.0	18.0	25.0
Compound	197	65.0	35.0	14.0	50.0
Weathering	197	57.0	43.0	18.0	70.0
Atmosphere	197	84.0	16.0	53.0	35.0

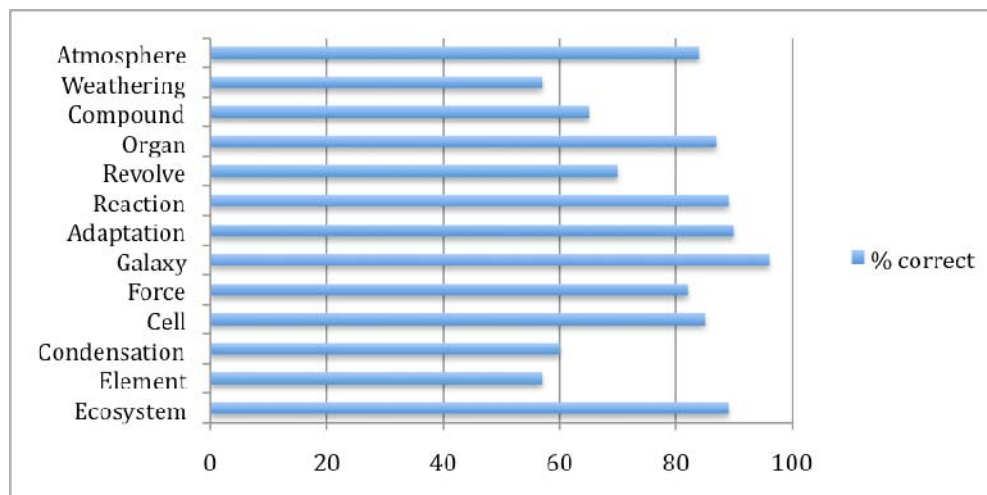


Figure 4.9. Percentage correct of Conceptual Science Vocabulary.

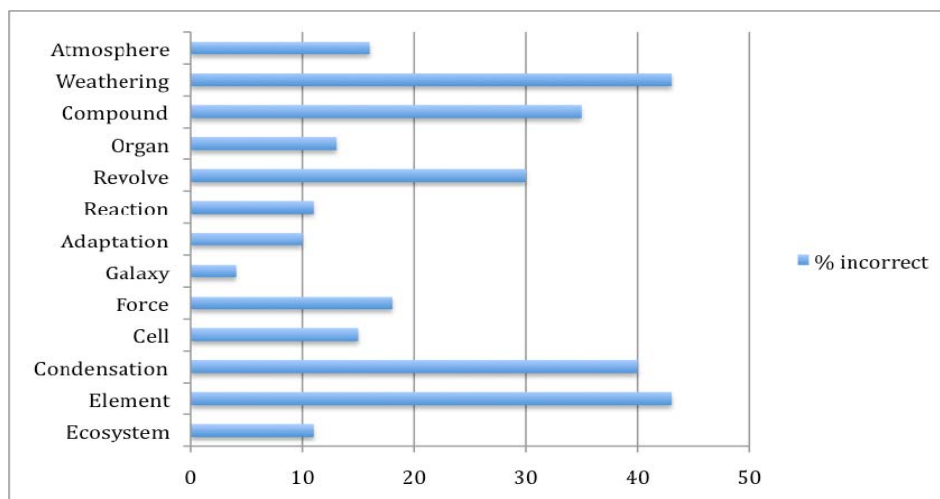


Figure 4.10. Percentage incorrect of conceptual science vocabulary.

DLD or PWLD students found conceptual vocabulary in the form of nominalisation (verbs which have been transformed into nouns) difficult. Figure 4.11 shows the incorrect responses levels for these students for these particular words, which include ‘condensation’ (85% incorrect), ‘reaction’ (45% incorrect) and ‘adaptation’ (35% incorrect). This supports research that nominalised words can cause considerable comprehension difficulties (Fang, 2006). Science has a considerable number of nominalised words in its subject-specific vocabulary. This could be one of the reasons for the lower achievement on the conceptual science vocabulary scale for these students.

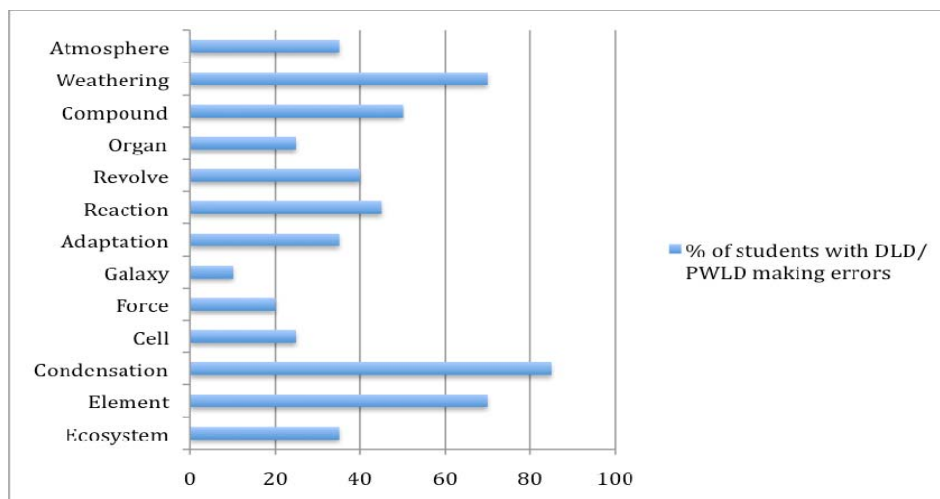


Figure 4.11. Percentage of students with DLD/PWLD making errors.

While there were items with which all groups of students experienced difficulties (see Figure 4.10), as well as nominalised words, students in the DLD and PWLD groups made up a disproportionate number of incorrect responses. ‘Atmosphere’ and ‘galaxy’, which most students knew overall, were respectively unknown by 50% and 53% of students with language learning difficulties (see Figure 4.12).

This supports the earlier stated finding that membership of the language learning disability group has a large effect on understanding of conceptual vocabulary.

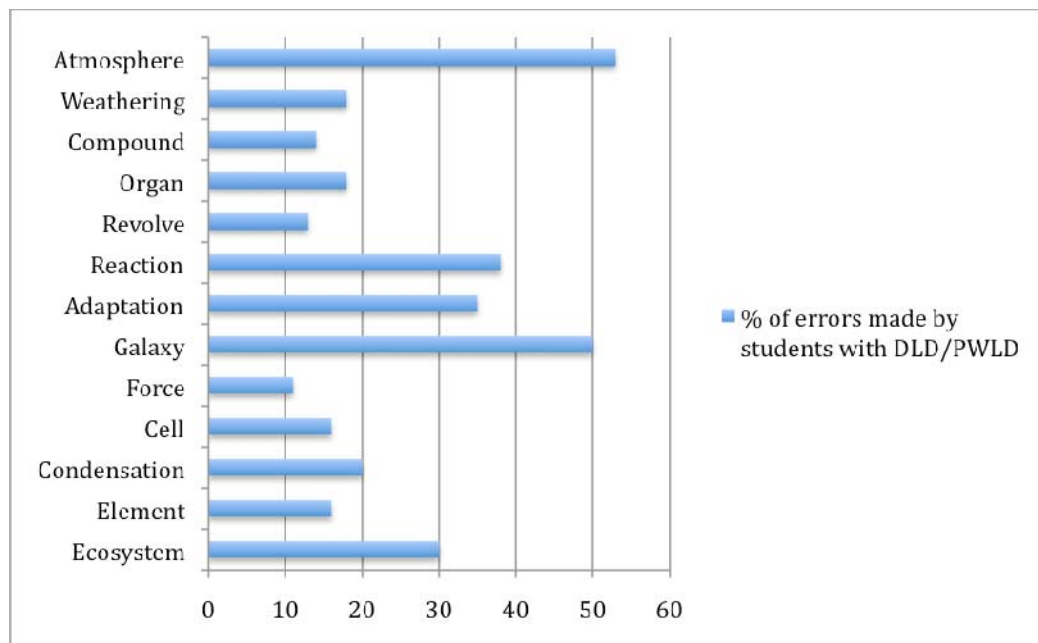


Figure 4.12. Percentage of errors made by DLD/PWLD students.

Across the three Science Vocabulary Survey scales, there is a range of responses. Students scored most highly on the concrete vocabulary scale and the least on the conceptual vocabulary scale. Students with a language learning disability recorded similar patterns, however, overall they experienced difficulties with all vocabulary scales. Nominalised words, words with semantically similar alternatives and abstract words all provided challenges for this group of students, who were overrepresented in number of errors for each item (up to 75%), compared with the percentage of participants in the sample (10%).

4.7.2 Attitude to science

Students responded to 10 statements using a 3-point Likert scale. Table 4.11 shows their responses to each of the statements as a percentage of the total sample.

Table 4.11
Student Responses to Items on the Attitude Scale

Item	% Disagree	% Unsure	% Agree	No response
1. I look forward to science lessons.	13	44	43	0
2. Science lessons are fun.	12	41	46	1
3. I enjoy the activities we do in science.	8	36	56	0
4. I find it easy to understand the words used in science.	15	36	48	1
5. I want to find out more about the world in which we live.	7	25	68	0
6. Finding out about new things is important.	1	12	86	1
7. I enjoy science lessons in this class.	11	36	53	0
8. I like talking to my friends about what we do in science.	31	37	32	1
9. We should have more science lessons each week.	57	30	13	0
10. I feel satisfied after a science lesson	17	47	36	0

There was a higher level of agreement than disagreement for the responses to all the statements except statement 9, which related to having more science classes each week. Only 13% of students wanted more classes, with 87% of students not sure, or not wanting extra classes. There was a wide range of positive scores (13% to 87%).

The two statements with the most positive responses were:

Statement 6: Finding out about new things is important (86%)

Statement 5: I want to find out more about the world in which we live (68%)

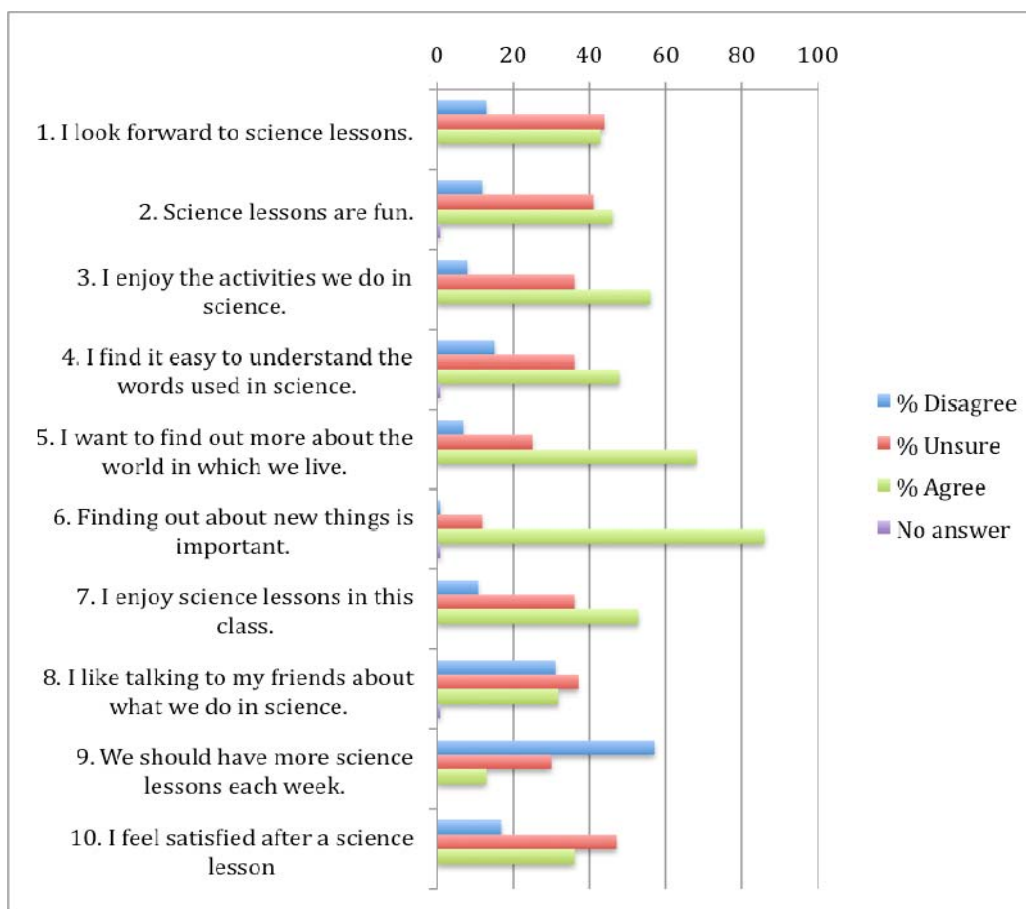


Figure 4.13. Student responses to individual items on the Attitude Scale.

The majority of students are clearly interested in the scientific world, however this level of positivity is not matched by their responses to statements relating to their science classroom and lessons (see Figure 4.13). While the majority of students enjoyed science activities (56%) and their science class (53%), only 36% of students reported feeling satisfied after a science lesson. There was considerable indifference to most aspects of science classes and a clear majority of students (57%) not wishing to have more science classes. 48% of students reported that it was easy to understand science words, which indicates that most students have some difficulties with science vocabulary.

4.8 SUMMARY

Mean scores for the Attitude Scale indicate that there is a positive attitude towards science for the combined Year 7 and 8 students participating in the research project. There were no significant differences between year-levels, however there were differences between female and male attitudes to science. Male students had a more positive attitude to science, although the female students in this study still had an overall positive attitude to science. Males also had a higher level of understanding of instructional vocabulary, which may link to increased levels of engagement in scientific investigation when compared with females (Jovanovich & King, 1998).

Mean scores for each of the vocabulary scales indicate that students found the concrete vocabulary task easiest of the three scales and the conceptual vocabulary task the most difficult. Effect size analysis revealed that students with a language learning disability, or presenting with one, are highly likely to experience difficulties understanding concrete and instructional vocabulary. Simple correlations revealed that understanding of instructional and conceptual vocabulary has a significant association with attitude to science. Membership of the group of students with a language learning disability has a large effect on attitude to science as well as understanding of conceptual vocabulary. Examination of individual items on the Science Vocabulary Scale also indicated that these students have specific areas of need relating to vocabulary, compared with their non-impaired peers.

The results from this study indicate that students with diagnosed language learning disabilities, or presenting with language learning disabilities, are at risk of having a less positive attitude to science than their peers, and are likely to experience difficulties understanding all types of science vocabulary, especially conceptual vocabulary.

The implications are that, along with building awareness of already known factors for increasing positive attitudes to science, such as teacher feedback and classroom environment, explicit teaching of instructional and conceptual vocabulary should be embedded in science classrooms, as the data indicate high levels of understanding of

instructional and conceptual vocabulary are associated with a more positive attitude to science.

The majority of students indicated an interest in the scientific world, however this level of positivity is not matched by their responses to statements relating to their science classroom and lessons. While a slim majority of students enjoy science activities and their science class, a clear minority reported feeling satisfied after a science lesson. There was considerable indifference to most aspects of science classes.

Less than half of the students reported that it was easy to understand science words, which indicates that most students have some difficulties with science vocabulary. As there are significant associations between understanding of specific types of science vocabulary and attitude to science, it is important to consider the implications for science teachers. These implications are discussed in Chapter 5.

CHAPTER 5

SUMMARY AND CONCLUSIONS

5.1 INTRODUCTION

This study was an investigation of the differences in students' understanding of secondary science vocabulary: concrete, instructional and conceptual. The study also sought to determine performances of different student groups in relation to their understanding of different vocabulary types and their attitudes to science. Associations between understanding of vocabulary types, and attitudes to science were investigated, as well as associations between the three types of science vocabulary.

The research was conducted in two secondary schools in Melbourne, Victoria, Australia, with 197 Year 7 and 8 students providing consent to participate in the study. The Progressive Achievement-tests – Reading (PAT-R), Ten-Item Attitude Scale and a candidate-generated Science Vocabulary Survey (SVS) were used to collect data.

An overview of the thesis is provided in Section 5.2 and a summary of the major findings is presented in Section 5.3. Significant contributions and limitations are considered in Sections 5.4 and 5.5 respectively. Recommendations for future research are made in Section 5.6.

5.2 OVERVIEW OF THESIS

This thesis consists of five chapters. Chapter 1 provided an overview of the thesis. It outlined the background to the study, including information about issues relating to students with language learning disabilities in secondary science, the importance of investigating students' understanding of secondary science vocabulary, and attitudes to science. The significance and objectives of the study were also described. The six research questions were:

Research Question 1:

What are the mean scores of the whole sample on the Attitude Scale and the Science Vocabulary Survey?

Research Question 2:

Are there associations between science vocabulary survey scales?

Research Question 3:

Are there associations between attitude to science and comprehension of science specific vocabulary?

Research Question 4:

Are there differences in the attitudes and comprehension of various types of science vocabulary, that is, concrete, instructional and conceptual, between different student groups?

Research Question 5:

Are there differences in science vocabulary knowledge between students with a language learning disability (diagnosed or undiagnosed) and students without a language learning disability?

Research Question 6:

What are students' responses to individual items on the Attitude Scale and Science Vocabulary Survey?

Chapter 2 reviewed literature relevant to the study. This included literature about general vocabulary acquisition and development, classification of vocabulary, associations between vocabulary, general comprehension and reading comprehension, the importance of oral vocabulary, and links between vocabulary and general academic subjects.

Literature specific to science was also reviewed and included the language of science, students' attitude to science, the transition from primary science classrooms to secondary science classrooms and gender differences.

Literature specific to students with language learning disabilities was also reviewed. This included vocabulary development, the academic impact of language learning disabilities, attitude to school in general and science specifically, and implications for teachers of these students.

In Chapter 3, the research design of the study was outlined. The research methods used were justified and described. The combination of a diagnostic reading comprehension assessment tool, and two online surveys were used to collect data. The selection of the three instruments (PAT-R, Ten-Item Attitude Scale and Science Vocabulary Survey) used in the study was discussed. Details of the administration of the instruments were provided. The method of selection of the sample was explained and the target population described. Finally, methods of data interpretation and types of data analysis were outlined.

Chapter 4 presented results and analysis of data relating to each research question. Relationships between and within the data were discussed. This included:

- Mean scores of the whole sample on the Attitude Scale and the Science Vocabulary Survey were presented and discussed
- Simple correlations between the three Science Vocabulary Scales were analysed
- Data investigating associations between attitude to science and comprehension of science specific vocabulary were presented and discussed
- Analysis of gender differences for attitude to science and comprehension of different types of science vocabulary was presented
- Analysis of year level differences for attitude to science and comprehension of different types of science vocabulary was presented
- Associations between group membership, attitude to science and understanding of each of the three science vocabulary scales were also investigated, with the results outlined
- Results of analysis of students' responses to individual items on the Attitude Scale and Science Vocabulary Scale were also explained

Chapter 5 concludes this thesis by providing an overview of the entire thesis. Major findings, contributions and limitations of the study are addressed and suggestions for future research are made at the conclusion of this chapter.

5.3 MAJOR FINDINGS OF THE STUDY

Research Question 1:

What are the mean scores of the whole sample on the Attitude Scale and the Science Vocabulary Survey?

A sample of 197 students from Years 7 and 8 in two Victorian secondary schools participated in this study. Of these, 179 students completed the Ten-Item Attitude Scale. This is less than the number of students completing the Science Vocabulary Survey, as several students did not provide all the required information. Descriptive statistics were used to determine the whole sample of students' mean scores and standard deviations. The mean average of 2.3 on the Attitude Scale (where responses were scored on a scale of 1- 3 with 3 being the most positive and 1 the least positive) indicated a positive attitude to science for the combined Year 7 and 8 participants.

The Science Vocabulary Survey consisted of three sections, each related to a specific vocabulary scale. Each section provided tasks associated with a specific type of science vocabulary: concrete, instructional or conceptual. Most of the 197 students who completed the Science Vocabulary Survey performed well on the Concrete Vocabulary scale of the Science Vocabulary Survey, with a mean score of 98.3%. The majority of students also performed well on the Instructional Vocabulary Scale of the Science Vocabulary Survey, with a mean score of 86%. A mean of 81.8% was scored on the Conceptual Vocabulary Scale. The mean scores for each of the vocabulary scales indicate that students found the tasks on the Concrete Vocabulary Scale easier than the tasks on the Conceptual Vocabulary Scale. These findings confirm the anecdotal evidence of the author.

Research Question 2:

Are there associations between science vocabulary survey scales?

The Science Vocabulary Survey consisted of three scales: Concrete Vocabulary Scale, Instructional Vocabulary Scale, and Conceptual Vocabulary Scale. A Pearson correlation analysis was used to determine simple correlations between the three scales. Associations were found between students' understanding of concrete vocabulary and instructional vocabulary. There were also associations found between students' understanding of instructional vocabulary and conceptual vocabulary, however, no associations were found between concrete vocabulary and conceptual vocabulary.

Research Question 3:

Are there associations between attitude to science and comprehension of science specific vocabulary?

A Pearson correlation analysis was used to determine simple correlations for the whole sample between attitude to science and understanding of science specific vocabulary. No specific associations were found between understanding of concrete vocabulary and attitude to science. However, significant associations were found between comprehension of instructional vocabulary and attitude to science, and comprehension of conceptual vocabulary and attitude to science. Thus, the implication is, students who perform well on the instructional vocabulary and conceptual vocabulary tasks are more likely to have a more positive attitude to science, while students who do not perform well on these tasks are more likely to have a less positive attitude to their science classes.

Research Question 4:

Are there differences in the attitudes and comprehension of various types of science vocabulary, that is, concrete, instructional and conceptual, between different student groups?

Three different types of groupings were investigated. This research question investigated whether or not gender, year-level or membership of a group relating to reading comprehension level or presence of a language learning disability was associated with differences in attitude and comprehension of different types of science vocabulary.

Descriptive analysis was used to find mean scores and standard deviations on the Attitude Scale and the three Science Vocabulary Scales for whole sample of male students and the whole sample of female students. A *t-test* for separate samples provided information about significant gender differences. As a group, Year 7 and 8 males had a more positive attitude to science. There were also significant differences between genders on the Instructional Vocabulary Scale, with males outperforming females. There were no significant differences on the Concrete Vocabulary Scale or Conceptual Vocabulary Scale.

Descriptive analysis was also used to find mean scores and standard deviations on the Attitude Scale and the three Science Vocabulary Scales for the whole sample of Year 7 students and the whole sample of Year 8 students. A *t-test* for separate samples provided information about the presence of significant year-level differences for the Attitude Scale and Science Vocabulary Survey Scales. No significant differences were found for the Attitude Scale or any of the Science Vocabulary Survey Scales. The implication is that students in this study are being well supported within their science classes, as the research indicates that students' attitudes to science usually decrease as they progress through secondary school (Morrell & Lederman, 1998).

An ANOVA, rather than *t-test*, was used to investigate differences between students who were grouped according to their PAT-R score or presence of a learning disability, as *t-test* results may become unreliable when used with more than two

samples (Choudhury, 2009). Data from five different groups were analysed. The F value created by ANOVA was significant for all scales (Attitude Scale and Science Vocabulary Scales), therefore post hoc tests were used to determine the significance between specific groups.

In relation to attitude to science, students in the PR47 and PR89 groups (average to above average reading comprehension levels) had a more positive attitude to science than students with a diagnosed language learning disability. Students in the top reading comprehension group (PR89) also had a more positive attitude to science than students presenting with a language learning disability (undiagnosed). There was no difference in attitude between the students grouped according to their level of reading comprehension. The results clearly indicate the impact the presence of a language learning disability (diagnosed or undiagnosed) has on a student's attitude to science, with these students likely to have a less positive attitude to science than their non-language learning disabled peers.

In terms of understanding of concrete science vocabulary, post hoc tests revealed that students with below average reading comprehension skills (PR13) performed significantly better than students with a language learning disability (diagnosed or undiagnosed). No other significant differences were evident, including differences between the different reading comprehension groups.

Results of the post hoc tests analysing understanding of instructional science vocabulary revealed that students in the average reading comprehension group (PR47) performed significantly better than the students with a diagnosed language learning disability and the students with below average reading comprehension skills. The students with above average reading comprehension skills (PR89) performed significantly better than those students with a language learning disability (diagnosed or undiagnosed). As with the data from the Attitude Scale and the Concrete Vocabulary Scale, there were no significant differences between groups of students organised according to their reading comprehension levels.

Significant differences were revealed between groups on the Conceptual Vocabulary Scale. The average reading comprehension group (PR47) performed significantly

better than the students with a diagnosed language learning disability and the students with below average reading comprehension skills. The students in the above average reading comprehension skills group (PR89) performed significantly better than those students with a language learning disability (diagnosed or undiagnosed), and those students with below average reading comprehension skills (PR13).

In summary, students with a language learning disability (diagnosed or undiagnosed) performed at a significantly lower level on all scales of the Science Vocabulary Survey and had a less positive attitude to science than their non-learning disabled peers. The absence of significant differences between reading comprehension levels and the four scales indicates that reading comprehension skills alone do not predict a student's ability to comprehend science specific vocabulary. It is more likely that underlying language difficulties of the language learning disabled student underpin their ability to comprehend different types of science vocabulary, the levels of which are associated with attitude to science.

Research Question 5:

Are there differences in science vocabulary knowledge between students with a language learning disability (diagnosed or undiagnosed) and students without a learning disability?

A *t-test* was used to determine whether or not there were differences in science vocabulary between students with a language learning disability (diagnosed or undiagnosed), and students without a language learning disability. Scores indicated that there were significant differences for all Attitude Scale and Science Vocabulary Scale means. Effect sizes were then calculated to determine the magnitude of group membership. The effect size results revealed that membership of the group of students with a language learning disability (diagnosed or undiagnosed) has a medium effect on understanding of concrete and instructional vocabulary, and a large effect on attitude to science and understanding of conceptual vocabulary. The implications are that students with a language learning disability (diagnosed or undiagnosed) are likely to experience difficulties understanding all types of science

vocabulary and be at risk of developing a less positive attitude to science than their non-learning disabled peers.

Research Question 6:

What are students' responses to individual items on the Attitude Scale and Science Vocabulary Survey?

Individual items on the Attitude Scale and the Science Vocabulary Survey were analysed according to percentage correct, percentage incorrect, percentage errors made by students with a language learning disability (diagnosed or undiagnosed), and the percentage of students with a language learning disability who gave an incorrect response to an item.

In the concrete vocabulary tasks, most students were able to match the terms for different pieces of science equipment with their corresponding photographs. Most errors were semantic, with students having difficulties with 'graduated cylinder', 'microscope' and 'flask'. The errors made by students with a language learning disability were not atypical, with 40% of these students mistakenly identifying 'microscope' as 'telescope'. This may be due to semantic or phonological errors. Very few errors were made overall, however students with a language learning disability (diagnosed or undiagnosed) were more likely to make an error when the alternatives were semantically or visually similar.

There was a wide range of responses on the Instructional Vocabulary Scale, where students matched a description to the target word. Overall, 86% of responses were correct, however, correct responses to individual items ranged from 58% to 98%. Students with a language learning disability (diagnosed or undiagnosed) experienced difficulties with key terms, such as 'compare' and 'discuss', which are used for scientific investigation and discussion. They also had the greatest difficulties with words commonly used in science classrooms, such as 'explain', 'observe' and 'gather'.

Overall, the Conceptual Vocabulary Scale items were the most difficult for all the students. As with the Instructional Vocabulary Scale items, students matched a description to the target word. There was an uneven spread of responses across the items, with a range of 57% to 96% correct for individual items. Students with a language learning disability (diagnosed or undiagnosed) found nominalised words (verbs which have been transformed into nouns) particularly difficult, with 85% of DLD/PWLD students providing an incorrect response to 'condensation' and 45% an incorrect response to 'reaction'. The results of the analysis of individual items on the Conceptual Vocabulary Scale support the conclusion that membership of the group of students with a language learning disability (diagnosed or undiagnosed) has a large effect on understanding of conceptual vocabulary.

Across the three Science Vocabulary Scales, students scored most highly on the Concrete Vocabulary Scale and the least on the Conceptual Vocabulary Scale. This is consistent with the candidate's anecdotal evidence. Students with a language learning disability (diagnosed or undiagnosed) also scored more highly on the concrete vocabulary tasks than the conceptual vocabulary tasks, however, this group of students was over-represented in the number of errors for each item (up to 70%) when compared with their representation within the whole sample (10%).

When considering students' responses to the Attitude Scale, it is important to note that while the participants had an overall positive attitude to science, there was a wide range of positive scores for each item (13% to 86%). Item 9, which related to having more science classes each week, received only 13% positive responses. Item 6, which stated that finding out new things was important, received 86% positive responses. It is important to note too that only 48% of students indicated that they found it easy to understand the words used in science, implying that more than half of students do not find it easy.

Statements which related to individual students' thoughts about the scientific world, rated higher than statements relating to the environment in which they were learning about science. Students expressed an interest in learning about science but were less positive about the ways in which they were being engaged in science at school. This finding will have important implications for teachers of science.

5.3.1 Summary of Major Findings

A summary of the major findings of this study follows:

- There were no significant year-level differences for attitude to science or understanding of science specific vocabulary
- Male participants had a more positive attitude to science than female participants
- Male participants had a greater understanding of instructional vocabulary which are key words in scientific investigation and discussion
- Overall, students performed better on the concrete vocabulary tasks than the instructional vocabulary and conceptual vocabulary tasks
- There is a significant association between students' understanding of instructional vocabulary and conceptual vocabulary
- There is a significant association between students' understanding of concrete vocabulary and instructional vocabulary
- There is no significant association between students' understanding of concrete vocabulary and conceptual vocabulary
- Students who perform well on instructional vocabulary and/or conceptual vocabulary tasks are likely to have a more positive attitude to science than their peers who don't perform as well on these tasks
- Students with a language learning disability (diagnosed or undiagnosed) have a less positive attitude to science than students with above average reading comprehension skills
- The presence of a language learning disability (diagnosed or undiagnosed) has a clear impact on attitude to science
- Students with a language learning disability (diagnosed or undiagnosed) do not perform as well on concrete vocabulary tasks, as students with below average reading comprehension skills
- Reading comprehension skill level is not associated with understanding of concrete or instructional vocabulary
- Reading comprehension skill level is associated with understanding of conceptual vocabulary, with significant differences between students with

below average reading comprehension skills and those with above average reading comprehension skills

- Membership of the group of students with a language learning disability (diagnosed or undiagnosed) has a medium effect size on understanding of concrete and instructional vocabulary
- Membership of the group of students with a learning disability (diagnosed or undiagnosed) has a large effect size on understanding of conceptual vocabulary and attitude to science
- Students with a language learning disability (diagnosed or undiagnosed) are overrepresented when incorrect responses for individual items on the Science Vocabulary Scale are analysed
- Examination of individual items on the Science Vocabulary Scale indicates that students with language learning disability have specific areas of need in relation to vocabulary, compared with their non-learning disabled peers
- Students with a language learning disability (diagnosed or undiagnosed) are at greater risk of having a less positive attitude to science than their peers, and they are likely to experience difficulties with all types of science vocabulary, especially instructional and conceptual vocabulary.

5.4 SIGNIFICANT CONTRIBUTIONS OF THE STUDY

5.4.1 Significant Contributions to the Field of Subject-specific Vocabulary

There has been considerable research into general vocabulary acquisition (Dealy et al., 2007), vocabulary comprehension (Beck & McKeown, 1985, 1991; Nagy & Scott, 2000) and subject-specific vocabulary (Beck et al., 2002; Hiebert & Lubliner, 2008; Marzano, 2010; Marzano & Pickering, 2005; Nagy & Townsend, 2012). Information from this study will add to this general body of research but also provide further information about the links between vocabulary and reading comprehension (Durso & Shore, 1991; Miller & Gildea, 1987; Stahl, 1999; Stanovich, 1986), and in particular, conceptual vocabulary. It provides information about differences in understanding of concrete, instructional and conceptual science vocabulary, building

on observations made by Woodward and Noell (1991) who noted that non-concrete words were more difficult to learn, possibly due to their abstract nature.

It also provides information about the difficulties that specific groups of students may experience in terms of vocabulary acquisition and understanding. This study supports previous research about different degrees of difficulty in vocabulary acquisition, specifically in the science domain (Sim, 1996; Woodward & Noell, 1991). The development of the Science Vocabulary Survey in the investigation, provides teachers and researchers with a new questionnaire that can be used to probe students' understanding of different types of science vocabulary.

5.4.2 Significant Contributions to the Field of Science Education

This study contributes information to the field of science education by investigating secondary science students' understandings of different types of science vocabulary: concrete, instructional and conceptual. A review of the literature indicated that conceptual language is more difficult to learn than concrete language (Woodward & Noell, 1991), particularly in science (Sim, 1996). This study explores the differences in understanding between concrete and conceptual vocabulary, and also instructional vocabulary. It highlights the links between understanding of science vocabulary and attitude to science, as students who perform poorly on instructional vocabulary and conceptual vocabulary tasks are more likely to have a less positive attitude to science than their peers who perform well on these tasks. This has implications for secondary science teachers.

First, teachers should be made aware of students with language learning disabilities, who are at risk of comprehension difficulties with instructional and conceptual vocabulary in particular. These students will also be at risk of a less positive attitude to science. Research has shown that explicit teaching of subject-specific vocabulary increases comprehension (Marzano et al., 2001), and is particularly important for students with language learning disabilities (Jitendra, et al., 2004; Spear-Swerling, 2006). This research should help to increase teacher awareness of the impact of vocabulary on students' comprehension levels and attitude to their classes. Secondly, teachers need to be provided with opportunities to update their knowledge of

vocabulary development and explicit teaching of subject-specific vocabulary, as well as provision of appropriate resources.

5.4.3 Significant Contributions to the Field of Language Learning Disabilities

This study contributes to the body of research about students with language learning disabilities. While considerable research has investigated these students' language acquisition, literacy and oral language skills, there is less research targeting adolescents and even less studying their attitudes to school and science in particular. There also appears to be an absence of data about these students' understanding of secondary science vocabulary (Orange, 2007). Starling, Munro and Togher's 2008 systematic review of randomised controlled trials (as cited in Starling et al., 2011b) revealed only 20 trials targeting language intervention for adolescents, but none of these targeted vocabulary development in the adolescent years. This finding was supported by Jitendra, et al. (2004). While this study does not target vocabulary intervention, it does contribute information about the types of vocabulary which students with language learning disabilities may find difficult. It highlights associations between understanding of secondary science vocabulary and attitude to science, as well as the effect size of belonging to the group of students with language learning disabilities.

5.4.4 Implications for Teaching and Learning

This study provides information about links between understanding of secondary science vocabulary and attitude to science. It highlights the need to be aware of students with language learning disabilities (diagnosed or undiagnosed) in the science classroom, as membership of this group has a medium to large effect size on their ability to understand science vocabulary and their attitude to science.

Science teachers need to ensure that instructional and conceptual vocabulary, in particular, are explicitly taught to all students. They should be particularly aware of any students with a language learning disability in their classrooms because of the potential for disengagement. There is a large body of research and considerable resources available which support explicit teaching of subject-specific vocabulary.

It may be advantageous to screen students' understanding of instructional vocabulary at the start of secondary school to ascertain their understanding of key words necessary for scientific investigations and discussion.

Results of the Attitude Scale indicated that while participants had high levels of interest in learning about their world and new things, they were less positive about their learning environment. It will be important for science teachers to consider teacher feedback, teacher dialogue, provision of opportunities for discussion and hands on activities, as well as time to revisit difficult words and concepts.

5.5 LIMITATIONS OF THE STUDY

One of the main limitations of the study was the number of participants (197) and that only two schools participated in the research. Although over 400 students were invited to participate in the study, only 197 gave written consent. It was necessary for active, rather than passive consent to be given for this research, however an almost 50% response rate should be considered quite high. As only small numbers of students participated, care should be taken when extrapolating the results of the study to the broader group of Year 7 and 8 secondary school students.

In this study, students with language learning disabilities were allocated to one group. They were not differentiated according to different learning disabilities such as language disorders, dyslexia, and Asperger's, although the majority of students in this group, and the group who presented with an undiagnosed learning disability, had a language disorder. More refined grouping may produce different results within the learning disabled group.

The Attitude Scale and the Science Vocabulary Scale were completed online because this was a more efficient way to collate data and administer the surveys. It also allowed for colour photographs to be used and limited the amount of paper used. One limitation was that once students submitted their responses, it was not possible to retrieve them. As a result, some students omitted their student code so their responses were unable to be used.

It would have been desirable to include qualitative data in the research design. It would also have been useful to conduct interviews with science teachers about their perceptions of students with language learning disabilities and their understandings of strategies needed to support these students. It would have been useful to provide students with an opportunity to provide more feedback about science vocabulary in particular. However, the collection of qualitative data was not undertaken in this study due to time constraints, and the potential to have a negative impact on teachers' and students' learning time.

5.6 RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

This study provides data which can be used for future research investigating secondary students' understanding of science vocabulary, particularly those with a language learning disability, and attitude to science. It should be noted again, as in Section 5.5, that this study was limited to 197 students from only two schools in metropolitan Melbourne, Australia. Any future studies should include a greater number of participants as well as a wider range of schools.

It may be useful for future research to differentiate between different types of language learning disabilities to identify whether or not this has an impact on understanding of science vocabulary and/or attitude to science. The Science Vocabulary Survey is a new questionnaire which can be used by researchers to further investigate students' comprehension of different types of science vocabulary, including those students with a language learning disability.

Finally, it may be useful to include qualitative data collection methods to investigate science teachers' understandings of students with language learning disabilities, and their knowledge of different methods for explicit teaching of Science vocabulary. It may also be beneficial to investigate the outcomes of using explicit instruction of Science vocabulary with language learning disabled adolescents, as there is a paucity of research in this area. Qualitative methods could also be used to provide students with the opportunity to provide more detailed feedback about their understanding of

secondary science vocabulary and how they perceive it impacts on their attitude to science.

5.7 SUMMARY

This study supports research that concrete vocabulary is more difficult to understand than conceptual vocabulary. It also supports the finding that males have a more positive attitude to science than females (Morrell & Lederman, 1998; Simpson & Oliver, 1986), although the females in this study still had an overall positive attitude to science.

Statistically significant associations were found between level of understanding of instructional vocabulary and conceptual vocabulary, and attitude to science. The most positive attitudes to science belonged to students who performed well on instructional and conceptual vocabulary tasks. Conversely, students with a less positive attitude to science were more likely to have performed less well on the instructional and conceptual vocabulary tasks. Therefore, it is important for teachers to be aware of this association, so they can explicitly teach key instructional and conceptual vocabulary, not only to increase comprehension levels, but also increase attitude to science in secondary school. Typically, students become less positive in their attitude to science as they progress through secondary school. Explicit teaching of instructional and conceptual vocabulary may be one way to influence students' attitude and therefore retain them in science classrooms longer.

No year-level differences were found in this study in terms of attitude to science or understanding of Science vocabulary. If these findings were found in a larger scale study then this would suggest that students' attitudes to science were not becoming less positive as they move through secondary school, as indicated in the current research (Speering & Rennie, 1996).

Significant group differences were found in this study for understanding of science vocabulary and attitude to science. Membership of the group of students diagnosed with a language learning disability, or presenting with a language learning disability (undiagnosed) had a medium effect on understanding of concrete and instructional

vocabulary, and a large effect on understanding of conceptual vocabulary and attitude to science. The implications are that science teachers need to be aware of the presence of a language learning disability and the impact that this can have on comprehension of science specific vocabulary and attitude to science. They also need to be supported in a number of ways, including opportunities to increase their understanding of language learning disabilities, learn and use evidence based techniques, including explicit instruction of science specific vocabulary, and the provision of relevant resources.

There were a number of limitations to the study, the main one being that there were a small number of participants from only two metropolitan schools. This should not negate the findings, however, care should be taken when extrapolating to a wider population. It would be important to replicate the study with a larger number of participants and a wider range of students, including those in country regions.

In this study, the candidate aimed to explore why some students, particularly those with a language learning disability, experience difficulties with secondary science and generally have a poor attitude towards science. This is outlined in Chapter 1. While there are clearly many factors which influence a student's attitude to science, the candidate was keen to investigate the influence of subject-specific vocabulary on attitude to science as well as explore whether or not there were differences in understanding of different types of science vocabulary: concrete, instructional and conceptual. The candidate was also aware of the limited amount of research into the topic being investigated, which specifically includes students with a language learning disability, so this study was also about adding to the current research for this population. The results of this study support the candidate's observation that students with language learning disabilities find subject-specific vocabulary difficult to learn and as a result have a less positive attitude to science. Through the literature review in Chapter 2, the candidate also discovered that there were many techniques and tools which can be used to increase students' comprehension levels (Cervetti et al., 2012; Bryant et al., 2003; Spear-Swerling, 2006). This study helps to justify why it is important for teachers of students with language learning disabilities to be aware of these techniques and tools.

It is hoped that this study will help to increase awareness of the difficulties that students with language learning disabilities experience, particularly in secondary school and result in more students being identified, assisted and feeling more positive about secondary science classes, and learning in general.

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Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

APPENDIX A

SCHOOL PRINCIPAL INFORMATION SHEET

My name is Charlotte Forwood. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology.

Purpose of Research

I am investigating differences in understanding of science vocabulary in secondary science students. I hope that this project will provide me with information that can be used to help students to engage and succeed in science.

The Role of Your Students

I am interested in finding out what your students understand about different types of science vocabulary.

I would also like to find out your students' attitude to science.

I will ask your students to complete a reading assessment (PAT-R), science attitude questionnaire and science vocabulary survey.

This process will take approximately 90 minutes.

It will take place over a period of time.

Any students presenting with a language learning difficulty will not need to complete the reading assessment, unless it is part of the school assessment program. Their time involvement will be less.

The Role of the School

I will need the school's assistance to hand out and collect Parent/Student Information forms and consent forms.

I will need the school to administer the assessments and survey.

I will need to be provided with an opportunity to run information sessions for parents, students and teachers.

The Role of the Researcher

I will provide the school with the appropriate assessment resources and access to the attitude survey. Scoring of the PAT-R will be completed by ACER. There will be no associated cost for the school. The school will receive a copy of the reading assessment data to use for diagnostic purposes.

I will collect and analyse the data.

I will write an interim report and a final report for the school.

I will offer the school professional development for teachers at the completion of the research project.

Consent to Participate

The students' involvement in the research is entirely voluntary. They have the right to withdraw at any stage without it affecting their rights or my responsibilities. When the students and their parents have signed the consent forms I will assume that they have agreed for their child to participate and allow me to use their data in this research.

Confidentiality

The information provided will be kept separate from the students' personal details, and only myself and my supervisor will have access to this. The science attitude questionnaire and science vocabulary surveys will not be named or have any other identifying information on them and in adherence to university policy, information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed. The reading tests will be part of your school's testing program. As such the school will have access to these results for diagnostic purposes.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number HR73/2009). If you would like further information about the study, please feel free to contact me on 03 8779 7559 or by email talking.ed@mac.com. Alternatively, you can contact my supervisor Professor Darrell Fisher on 08 9266 3110 or D.Fisher@curtin.edu.au

**Thank you very much for your involvement in this research.
Your participation is greatly appreciated.**

APPENDIX B

STUDENT INFORMATION SHEET

My name is Charlotte Forwood. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology.

Purpose of Research

I am investigating what secondary students know about science vocabulary (words used in science lessons).

Your Role

I am interested in finding out what you understand about different types of science vocabulary.

I would also like to find out what you think about science and science classes.

I will ask you to complete the following:

- a reading test,
- a questionnaire (which will ask you what you think about science)
- a science vocabulary survey

This process will take approximately 90 minutes.

It will take place on more than one day.

I hope that this project will provide me with information that can be used to help students to enjoy and succeed in science.

Consent to Participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. When you and your parent(s) have signed the consent forms I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information provided will be kept separate from your personal details, and only myself and my supervisor will have access to this. The science attitude questionnaire and science vocabulary surveys will not be named or have any other identifying information on them. According to university policy, information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

The reading tests may already be a part of your school's testing program. As such your school will have access to these results to help them provide the most appropriate teaching programs.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number HR73/2009). If you would like further information about the study, please feel free to contact me on 03 8779 7559 or by email talking.ed@mac.com. Alternatively, you can contact my supervisor Professor Darrell Fisher on 08 9266 3110 or D.Fisher@curtin.edu.au

**Thank you very much for your involvement in this research.
Your participation is greatly appreciated.**

APPENDIX C

PARENT INFORMATION SHEET

My name is Charlotte Forwood. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology.

Purpose of Research

I am investigating differences in understanding of science vocabulary in secondary science students.

Your Child's Role

I am interested in finding out what your child understands about different types of science vocabulary.

I would also like to find out your child's attitude to science.

I hope that this project will provide me with information that can be used to help students to engage and succeed in science.

I will ask your child to complete a reading comprehension test, science attitude questionnaire and science vocabulary survey.

This process will take approximately 90 minutes.

It will take place over a period of time.

Consent to Participate

Your child's involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. When you and your child have signed the consent forms I will assume that you have agreed for your child to participate and allow me to use their data in this research.

Confidentiality

The information provided will be kept separate from your child's personal details, and only myself and my supervisor will have access to this. The science attitude questionnaire and science vocabulary tests will not be named or have any other identifying information on them and in adherence to university policy, information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

The reading tests may already be a part of your school's testing program. As such your school will have access to these results to help them provide the most appropriate teaching programs.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number HR73/2009). If you would like further information about the study, please feel free to contact me on 03 8779 7559 or by email talking.ed@mac.com. Alternatively, you can contact my supervisor Professor Darrell Fisher on 08 9266 3110 or D.Fisher@curtin.edu.au

**Thank you very much for your involvement in this research.
Your participation is greatly appreciated.**

APPENDIX D
PARENT CONSENT FORM

- I understand the purpose of the study and what my child will be required to do.
 - I have been provided with the participation information sheet.
 - I understand that the procedure itself may not benefit my child.
 - I understand that my child's involvement is voluntary and he/she can withdraw at any time without problem.
 - I understand that no personal identifying information like my child's name and address will be used in any published materials.
 - I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
 - I have been given the opportunity to ask questions about this research.
 - I agree for my child to participate in the study outlined to me.
-

Name: _____

Son/daughter's name: _____

Class: _____

Signature: _____

Date: _____

Investigator: Charlotte Forwood Signature: _____

APPENDIX E
STUDENT CONSENT FORM

- I understand the purpose of the study and what I will be required to do.
 - I have been provided with the participation information sheet.
 - I understand that the procedure itself may not benefit me.
 - I understand that my involvement is voluntary and I can withdraw at any time without problem.
 - I understand that no personal identifying information like my name and address will be used in any published materials.
 - I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
 - I have been given the opportunity to ask questions about this research.
 - I agree to participate in the study outlined to me.
-

Name: _____

Year: _____

Form/Class: _____

Signature: _____

Date: _____

Investigator: Charlotte Forwood

Signature: _____

APPENDIX F

TEN-ITEM ATTITUDE SCALE

Attitudes to Science

Items 1 - 10 below consist of a number of statements about any science lessons you might have in this class.

You will be asked what you think about these statements. There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

For each statement, click on the circle next to:

- disagree if you disagree with the statement
- not sure if you are not sure
- agree if you agree with the statement.

Please enter your student ID. (Your teacher will provide you with this information.)

Click on the correct survey code. (Your teacher will let you know which code to click.)

- ☐ DLD
- ☐ PWLD
- ☐ PR13
- ☐ PR47
- ☐ PR89

Which year are you in?

- ☐ Year 7
- ☐ Year 8

Which gender are you?

- ☐ Male
- ☐ Female

Indicate the type of school you attend

- ☐ Boys only
- ☐ Girls only
- ☐ Boys and girls

1. I look forward to science lessons.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

2. Science lessons are fun.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

3. I enjoy the activities we do in science.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

4. I find it easy to understand the words used in science.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

5. I want to find out more about the world in which we live.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

6. Finding out about new things is important.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

7. I enjoy science lessons in this class.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

8. I like talking to my friends about what we do in science.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

9. We should have more science lessons each week.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

10. I feel satisfied after a science lesson.

- ☐ Disagree
- ☐ Not sure
- ☐ Agree

Submit

APPENDIX G

SCIENCE VOCABULARY SURVEY – ONLINE STUDENT VERSION

Science Vocabulary Survey

This science questionnaire aims to find out what you know about different types of science vocabulary. There are three sections.

Please enter your student ID. (Your teacher will give you this information.)

Click on the correct survey code (your teacher will let you know which code to click).

- ☐ DLD
- ☐ PWLD
- ☐ PR13
- ☐ PR47
- ☐ PR89

Which year are you in?

- ☐ Year 7
- ☐ Year 8

Which gender are you?

- ☐ Male
- ☐ Female

Indicate the type of school you attend

- ☐ Boys only
- ☐ Girls only
- ☐ Boys and Girls

SECTION 1

In this section, look at the words below.
Click on the picture which matches each word.

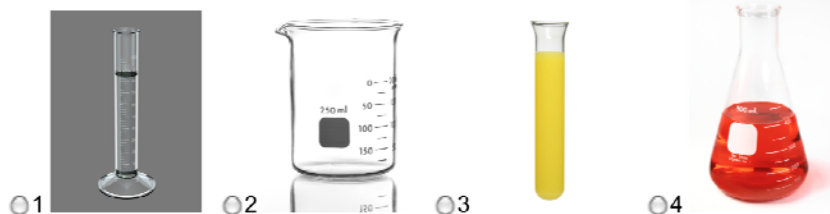
1. Select the picture which matches the word: pipette



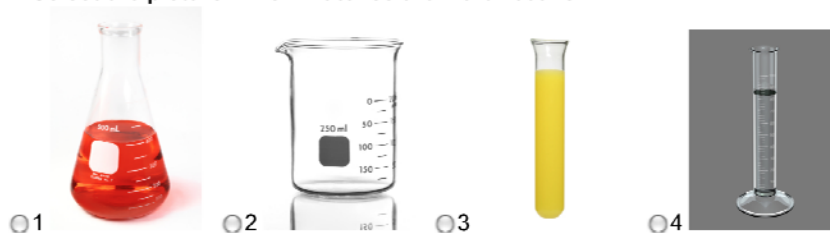
2. Select the picture which matches the word: petri dish



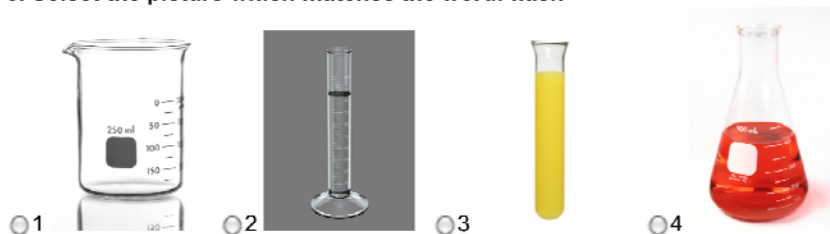
3. Select the picture which matches the word: test tube



4. Select the picture which matches the word: beaker



5. Select the picture which matches the word: flask



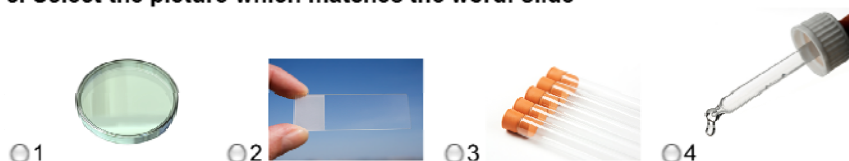
6. Select the picture which matches the word: microscope



7. Select the picture which matches the word: graduated cylinder



8. Select the picture which matches the word: slide



9. Select the picture which matches the word: balance



10. Select the picture which matches the word: stopper



SECTION 2

Read the following words which are used to give instructions.
Click on the best definition for each word.

13. analyse

- ☐ describe how things are the same or different
- ☐ look at the detail very closely
- ☐ show, using lots of examples

14. explain

- ☐ describe how things are the same or different
- ☐ give reasons for information
- ☐ show, using lots of examples

15. summarise

- ☐ use your own words to highlight the main points
- ☐ look at the detail very closely
- ☐ show, using lots of examples

16. observe

- ☐ describe how things are the same or different
- ☐ look at the detail very closely
- ☐ note how things look or change

17. explore

- ☐ find out about new things
- ☐ look at the detail very closely
- ☐ show, using lots of examples

18. compare

- ☐ describe how things are the same or different
- ☐ explain your point of view
- ☐ make something clear and simple

19. discuss

- ☐ describe how things are the same or different
- ☐ give important reasons for and against an idea and come to a conclusion
- ☐ show, using lots of examples

20. design

- ☐ describe how things are the same or different
- ☐ look at the detail very closely
- ☐ create a plan

21. question

- ☐ describe how things are the same or different
- ☐ look at the detail very closely
- ☐ ask for an explanation or explore an idea

22. gather

- ☐ find out information
- ☐ look at the detail very closely
- ☐ show, using lots of examples

SECTION 3

Read the following science words.
Click on the best definition for each word.

23. ecosystem

- ☐ a community of plants, animals and their environment
- ☐ an economic way of looking after the Earth
- ☐ an animal's habitat

24. element

- ☐ a substance that can be changed from one thing into another
- ☐ something that is found on electrical appliances
- ☐ a substance that cannot be changed into a simpler substance

25. condensation

- ☐ when something changes from a solid into a liquid
- ☐ when something changes from a liquid into a gas
- ☐ when something changes from a gas into a liquid

26. cell

- ☐ basic unit from which all organisms are made
- ☐ part of an atom
- ☐ the outside of an organ

27. force

- ☐ something that moves
- ☐ a push or a pull
- ☐ something which is very strong

28. galaxy

- ☐ a black hole
- ☐ a collection of stars, planets, gas and dust
- ☐ a place where astronauts travel to

29. adaptation

- ☐ plants and animals change to suit their environment
- ☐ what happens when animals become extinct
- ☐ plants and animals living together to survive

30. reaction

- ☐ a change in response to something
- ☐ a negative response to someone or something
- ☐ to move backwards suddenly

31. revolve

- ☐ to turn around
- ☐ to be at the centre of something
- ☐ to move in a clockwise direction

32. organ

- ☐ part of the body with a special function
- ☐ a group of cells working together
- ☐ the circulation system

33. compound

- ☐ a substance formed when two or more elements are combined but not chemically
- ☐ a substance formed when two or more elements are combined chemically
- ☐ a difficult idea

34. weathering

- ☐ changes to the climate
- ☐ global warming
- ☐ changes to the landscape caused by wind and water

35. atmosphere

- ☐ the mood of a place
- ☐ the gases and clouds surrounding a planet
- ☐ the edge of a planet

Thank you for completing this survey. Check that you have answered all the questions. Then click the 'submit' button below.

Submit

APPENDIX H

ETHICS APPROVAL

memorandum

To	Darrell Fisher, SMEC
From	A/Professor Stephan Millett, Chair, Human Research Ethics Committee
Subject	Protocol Approval HR 73/2009
Date	5 August 2009
Copy	Charlotte Forwood, 66 Empress Road, Surrey Hills, Vic, 3127 Graduate Studies Officer, Faculty of Science and Engineering



Office of Research and Development

Human Research Ethics Committee

TELEPHONE 9266 2784

FACSIMILE 9266 3793

EMAIL hrec@curtin.edu.au

Thank you for your application submitted to the Human Research Ethics Committee (HREC) for the project titled "Investigating Differences in Understanding of Vocabulary in Secondary Science". Your application has been reviewed by the HREC and is approved.

- You have ethics clearance to undertake the research as stated in your proposal.
- The approval number for your project is **HR 73/2009**. Please quote this number in any future correspondence.
- Approval of this project is for a period of twelve months **04-08-2009** to **04-08-2010**. To renew this approval a completed Form B (attached) must be submitted before the expiry date **04-08-2010**.
- If you are a Higher Degree by Research student, data collection must not begin before your Application for Candidacy is approved by your Faculty Graduate Studies Committee.
- The following standard statement **must be included** in the information sheet to participants:

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number HR 73/2009). The Committee is comprised of members of the public, academics, lawyers, doctors and pastoral carers. Its main role is to protect participants. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

Applicants should note the following:

It is the policy of the HREC to conduct random audits on a percentage of approved projects. These audits may be conducted at any time after the project starts. In cases where the HREC considers that there may be a risk of adverse events, or where participants may be especially vulnerable, the HREC may request the chief investigator to provide an outcomes report, including information on follow-up of participants.

The attached **FORM B** should be completed and returned to the Secretary, HREC, C/- Office of Research & Development:

When the project has finished, or

- If at any time during the twelve months changes/amendments occur, or
- If a serious or unexpected adverse event occurs, or
- 14 days prior to the expiry date if renewal is required.
- An application for renewal may be made with a Form B three years running, after which a new application form (Form A), providing comprehensive details, must be submitted.

Regards,


A/Professor Stephan Millett
Chair Human Research Ethics Committee